120 YEARS
1872–1992

SPECIAL ANNIVERSARY ISSUE

A Times Mirror Magazine

Popular Science

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197,658 MILES
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142,246 Miles
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126,979 Miles
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236,119 miles
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Popular Science

THE WHAT'S NEW MAGAZINE

AUGUST 1992
Founded in 1872 / Vol. 241, No. 2

COVER STORY

65

120 years of POPULAR SCIENCE

We have walked with men on the moon and seen the planets through the eyes of technology. We have traveled by automobile, high-speed train, and jet and investigated the infinitely large and small. In this special anniversary section, we take a fond look at the inventions and scientific achievements of the past 120 years.

CRISIS IN EDUCATION

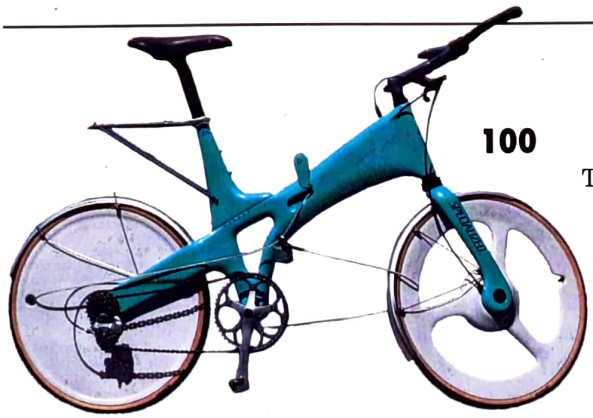
58

Science + Math = F

U.S. students rank near the bottom of the industrialized nations in science and math achievement, making them shockingly unprepared to face real-world challenges. The first in a series that examines this educational crisis.

Too hot to handle 52

More than two-thirds of the nation's radioactive waste sits in decaying steel tanks at Hanford Nuclear Reservation near Richland, Wash. Cleanup will be incalculably expensive and concern over workers' and townspeoples' health is mounting.



100

Bike to the future

Three radical new concept bikes feature advanced airplane-type suspension systems, integrated computers, and continuously variable transmissions. The payoff for the rider? Smoothness and improved performance.

WHAT'S NEW 10

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From The Editor

In 1872, Congress made Yellowstone the first national park, missionary Dr. David Livingstone was exploring Africa, Samuel F. B. Morse, inventor of the telegraph, died, and Jules Verne wrote *Around the World in Eighty Days*. By comparison, a watershed event in the life of Edward L. Youmans, a half-blind, self-taught writer, may have seemed less significant. With the manifesto "to interest the nonscientific public," Youmans launched *The Popular Science Monthly*. The first issue had a print run of 5,000 copies, an annual subscription price of five dollars, and included articles on "The Recent Eclipse of the Sun," "Hints on House Building," "Science and Immortality," and "The Causes of Dyspepsia."

Today, 120 years later, POPULAR SCIENCE is the largest science and technology publication in the world, with 1.8 million copies sold each month and a total readership of 4.5 million. Only six magazines have been continuously published longer: *The Atlantic* (1857), *Harper's* (1850), *Harper's Bazaar* (1867), *The Nation* (1865), *Scientific American* (1845), and *Town & Country* (1846).

JOHN B. CARNETT

Editor-in-chief Fred Abatemarco in the POPULAR SCIENCE library. More than a century later, the magazine founder's self-evaluation sounds understated: "I knew a good thing when I saw it."

Consider how much history we have witnessed during POPULAR SCIENCE's lifetime. Picasso, Lenin, Martin Luther King, Churchill, Roosevelt, Babe Ruth, and Buckminster Fuller made their marks on our lives. The automobile, the airplane, the zipper, the lightbulb, the ballpoint pen, aspirin, television, the atom bomb, computers, and peanut butter were invented. Indoor plumbing was installed in the White House, the Brooklyn Bridge was built and endures, the *Titanic* sailed and sunk, men have walked on the moon, and communism has come and gone.

It's not often that anyone or anything gets to mark a 120th anniversary. So we're celebrating in this issue with a special retrospective sampling of science and technology's highlights as they were originally covered in the pages of POPULAR SCIENCE.

We hope you enjoy the look back. POPULAR SCIENCE, obviously, has evolved with the times. Still, 1.2 centuries later, it remains true to Youman's original vision. In contemporary terms, our mission remains to be your window on the world of science and technology—informing, educating, and entertaining you with the exploration and demystification of what's new and how it affects your lives.

Something else of special significance in this issue: the first installment of a multipart series by Science and Technology Editor Arthur Fisher documenting our country's crisis in science and math education. The facts speak loudly that American children, teenagers, and college graduates are woefully unprepared to cope with an increasingly technological society.

In succeeding issues, Fisher will explore the causes for this dismal report card, and the potential remedies. I urge you to read this series and participate this month in our special telephone survey (see the details on page 61). The results of this poll—what you think could make a difference in the quality of science and math education—will be published at the conclusion of this series and distributed to educational policymakers and government officials throughout the country.

Fred Abatemarco

Editor-in-Chief

Popular Science

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Readers Talk Back

As easy as pie?

How could flying a plane be made as easy as driving a car, as you say in "Highway in the Sky" [June]? How about the things you have to know regardless of the cockpit layout and avionics systems—the plane's aerodynamics, airspace classifications, federal aviation regulations, emergency procedures, and more? What if the system failed and the pilot didn't know how to fly a regular plane?

Sean T. Kelley, Gunnison, Colo.

The system is still a research project —not a product that will be available soon. It will require communications/navigation data that are not widely available today.—Dawn Stover

Sun power by the mile

Photovoltaic systems can provide almost 100 megawatts of generating capacity on one square mile of land, not one megawatt as you stated in "Solar Cell Update" [June]. While it is correct that a nuclear or fossil-fuel plant could produce up to 4,000 megawatts per square mile, only Homer Simpson would want to live close to one of those. Also, when the additional land for waste storage and handling, and fuel mining and transportation is considered, the land issue becomes moot.

Michael J. Stern, president
Utility Power Group
Chatsworth, Calif.

We regret the typographical error.

The whole view

You gave an incomplete view of the technological infrastructure for the summer Olympic Games ["Electronics Newsfront," June]. You did not mention EDS, a key player that collects, calculates, and distributes all competition results in real time to 3.5 million spectators, media, athletes, and coaches at 2,200 locations throughout Barcelona.

Nancy Sharp
EDS Corp., Dallas, Texas

You got the wrong man

The *Gee Bee* pictured in "Ace of Air Racers?" [May] was flown by Lowell Bayles, not Jimmy Doolittle. Bayles also won the Thomson Trophy Race (before Doolittle). Later, in this same plane, Bayles tried for a new land speed record in Detroit. He was killed when his plane went out of control while traveling well over 300 mph about 75 feet above the ground. The *Gee Bee* that Doolittle flew, around 1933, was red and white, and had a pair of dice and the numbers 7 and 11 painted on the side. I was in the stands when Doolittle made the run; I had just had my 18th birthday, but I remember it as though it were yesterday.

Robert H. Meyer, Lakewood, Ohio

Black or white?

In "A Vehicle for Change" [June], you labeled the black-on-white instrument panel on page 103 as belonging to the Eagle Vision. But the Vision's is white on black. The Dodge Intrepid has black-on-white instrumentation.

Ed Tadross, Garden City, N.Y.

Reader Tadross is correct. Also, the lineup of cars on that page should have read (from the left) Chrysler Concorde, Dodge Intrepid, and Eagle Vision.

Industrial strength

Palm nailers are not new ["Home Newsfront," May]. Danair Inc., then called Aerosmith, developed and introduced them in 1967. The Pony Air, the tool you covered, is a Taiwanese copy.

D.G. Scilagyi, president
Danair Inc., Box 3893
Visalia, Calif. 93278

I neglected to say that Danair sells a professional-quality palm nailer with a variety of noses and guides for applications like washered roofing nails, finishing nails, and punching. Danair's standard nailer is $260—that is $160 more than the do-it-yourself version sold by Pony Air.—Phil McCafferty

Editor's notes: Inquiries for the Helmut Kase in "What's New" [June] may be directed to PM Design, 20298 Hunter Ct., Lakeville, Minn. 55044.

The Stars and Stripes '88 was designed by Duncan Maclane and David Hubbard, not Burt Rutan, as was stated in "From the Editor" [May].

Address letters to Readers Talk Back, POPULAR SCIENCE, 2 Park Ave., New York, N.Y. 10016. Or fax your letter to us at 212-481-8062. Letters may be edited for space and clarity. We regret that we cannot answer unpublished letters.

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WHAT'S NEW

EDITED BY MARCELLE M. SOVIERO AND JUDITH ANNE YEAPLE

RECYCLING PEGASUS

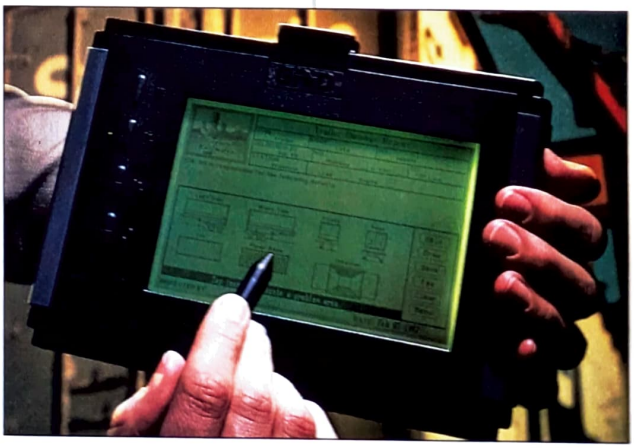
This fall, Orbital Sciences Corp. plans to roll out a larger, wingless version of the Pegasus rocket capable of carrying up to three times more payload. Called Taurus, the rocket will use Pegasus's guidance and control systems and its three rocket motors—plus one of its own. Unlike Pegasus, which is launched from an airborne B-52, Taurus will be ground-launched. The 88-foot-long, 150,000-pound rocket was developed under a contract from the Defense Advanced Research Projects Agency.

RIGHT ON TIME

The Junghans Mega clock is always accurate: It sets itself to the U.S. Bureau of Standards' atomic clock in Boulder, Colo. The clock's built-in antenna receives radio signals from a transmitter and its microprocessor moves the hands accordingly. Price: $275. Junghans Uhren GmbH, Box 100, D-7230 Schramberg, Germany.

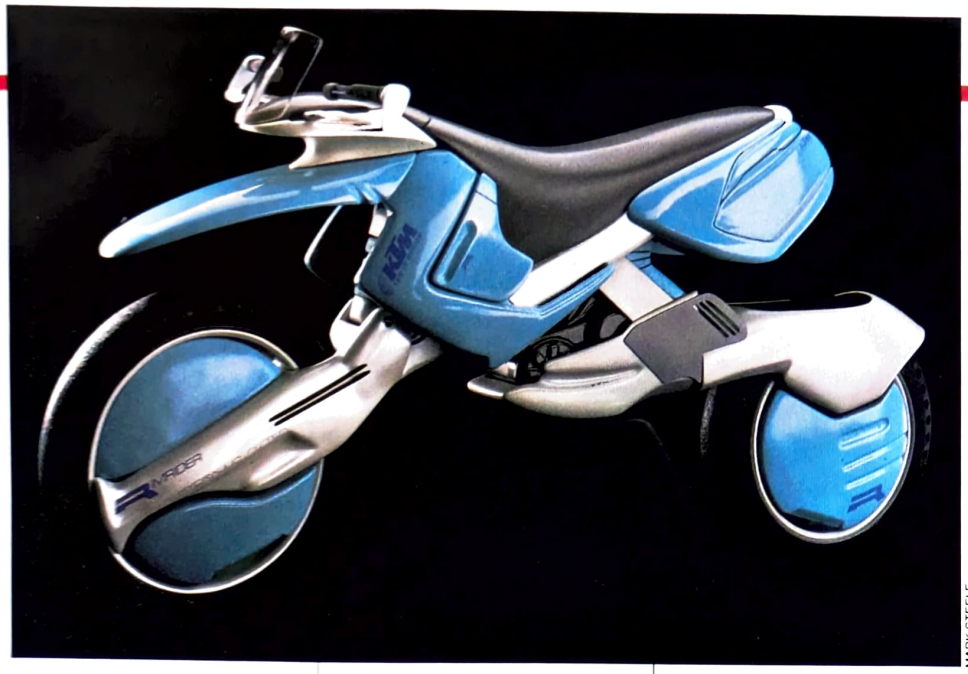
AS YOU LIKE IT

Like your coffee warm or extra hot? Braun's KF850 Aromaster Coffeemaker lets you adjust coffee temperature from 171°F to 189°F. An electronic sensor in the heating plate maintains the temperature, no matter how much coffee is in the carafe. The $99 appliance has a 24-hour timer and a carafe lid that prevents evaporation.



COMPUTERWEAR

Grid Systems' PalmPad, the first IBM-compatible computer you can wear, straps to your hand or wrist; data is entered with a pen as you walk, clipboard-style. The 2.8-pound computer is about the size of a hardcover book and stores data on credit-card-size "disks" that hold 20 megabytes each. Price: $2,895.



MARK STEELE

STYLISH CYCLE

The front wheel of the Rim Rider revolves around a stationary rim with no center hub, improving handling and reducing noise. The emissions system incorporates electronic synthesizers that reduce exhaust noise. Next World Design, 6566 Retton Rd., Reynoldsburg OH 43068.

LITTLE SAFETY LIGHT

Don't let its diminutive size fool you: The Cueliite personal safety light works for 200 hours and can be seen up to 2,000 feet away. Simply strap or clip the 1.5-ounce light to your sneaker, leg, or wrist. Price: $20. VistaLite, 2950 Old Tree Dr., Building 3, Lancaster PA 17603.

CONVERTIBLE CAMERA BAG

The main compartment of the Galen Rowell Modular Fanny Pack camera bag stores one motorized camera and up to six lenses; three external pockets hold supplies. Without the waist belt, the $150 bag can be worn on the shoulder. Photoflex, 541 Capitola Rd. Extension, Suite G, Santa Cruz CA 95062.

HIGH-TECH HOUSE CALL

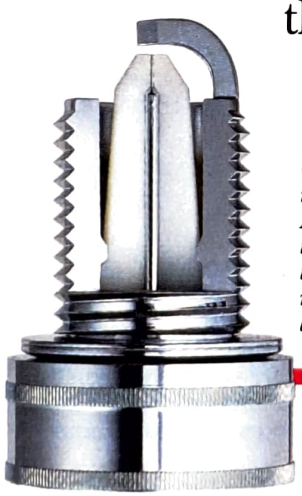
The portable MDphone Cellular Rescue unit, carried by firefighters and police, contains a cellular phone and electrode pads for administering defibrillation treatment to a cardiac-arrest victim. The unit automatically dials a participating hospital and transmits the victim's electrocardiogram. If necessary, a doctor activates the pads through the cellular hookup. Developed by MEDphone Corp. of Paramus, N.J., the system is in use in Atlanta and in Wilmington, Del.

STOP THE JITTERS

Sony's CCD-TR101 ultralight camcorder is the first to combine optical image stabilization and video Hi8 technology. Built-in sensors detect movement and adjust the angle of the active prism lens to prevent jitters. Additional features include a 10:1 zoom lens and digital camera signal processing for improved picture quality. Price: $1,800.

No matter where only one plug guarantees

A lot of spark plugs claim they'll give your car better performance. At Bosch, we guarantee it. No matter if your car was built across the street or across the world, if you don't feel the difference with Bosch Platinum, we'll pay for the plugs.*



The 99.9% Pure Platinum Center Electrode plus our extended insulator design give the Bosch Platinum plug a wider heat range than standard plugs. And the effective gap between its electrode and tip remains virtually unchanged over the life of the plug.

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*See store for details.

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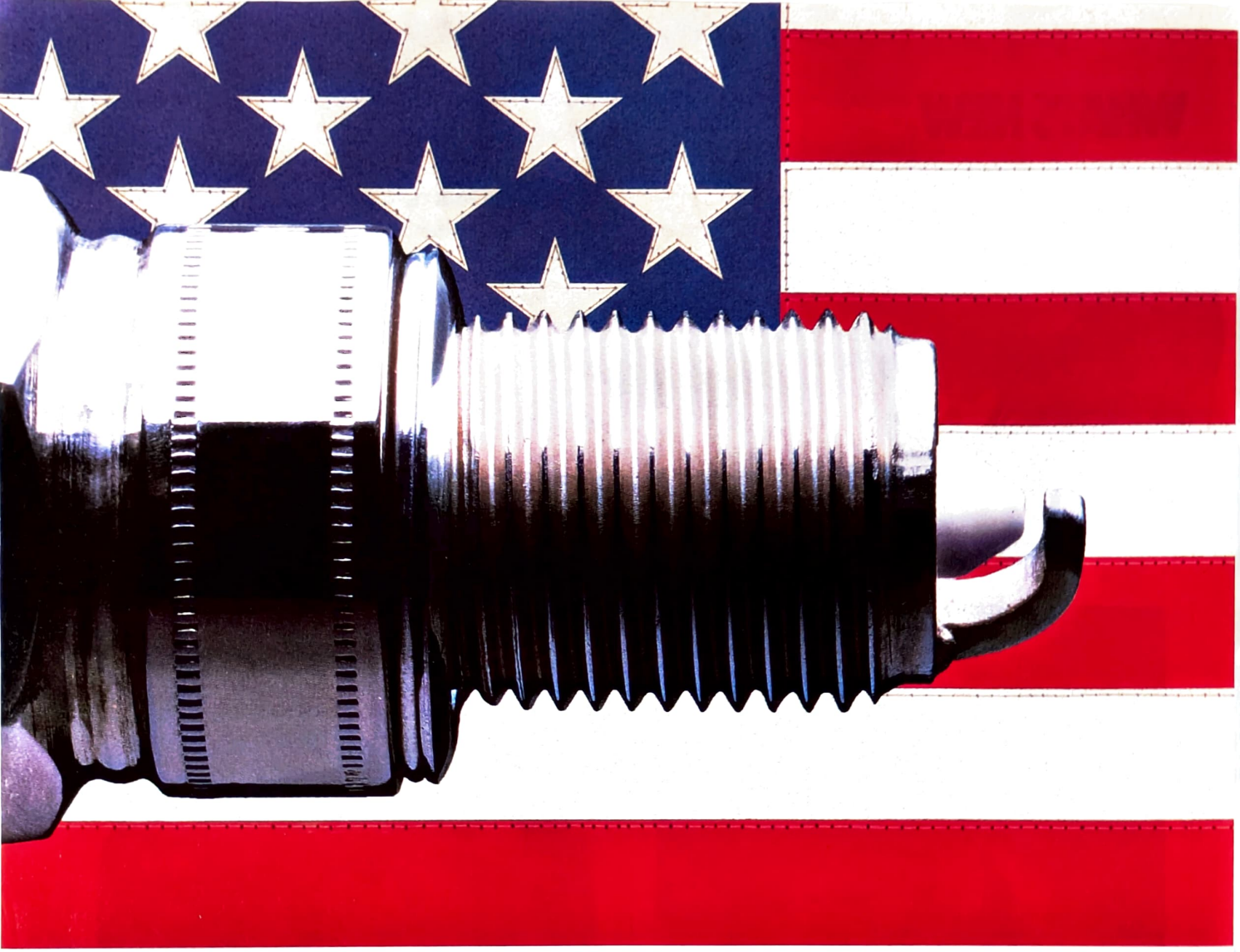

your car is from, better performance.

fact remains that it continues to be the only plug with a 99.9% pure platinum electrode engineered into a revolutionary extended insulator design.

The result is quicker starts, smoother acceleration and improved fuel efficiency.

So before you buy just any plugs, remember this, only one plug in the world guarantees better performance in import and domestic cars. Bosch Platinum.

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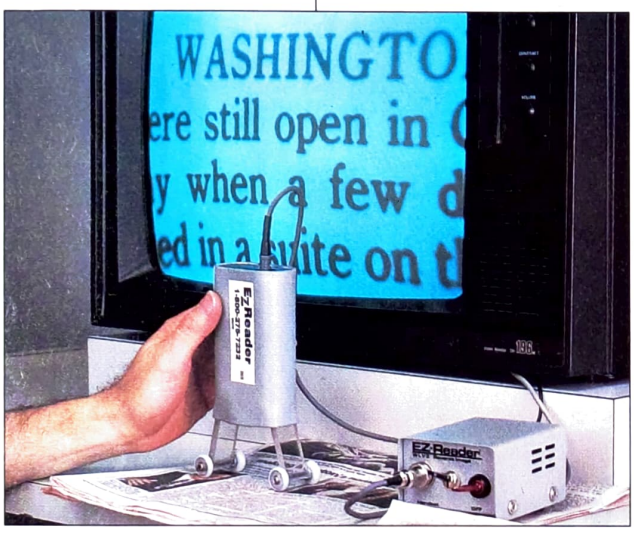
WHAT'S NEW

VERSATILE SUBARU

Subaru's turbocharged concept car, the four-cylinder Rioma, runs on any gasoline-methanol combination, up to a mixture of 85 percent methanol and 15 percent gasoline. Sensors in the 16-valve engine continually measure the fuel mix and adjust for peak performance. The car includes a five-speed manual transmission and dual-range all-wheel drive.

SANDER VAC

Sand&Kleen captures 90 percent of the dust particles generated when sanding plasterboard joint compound. The $60 tool uses the suction of a shop vacuum to pull debris into the sander and through a hose to a water-filled bucket. Magna Industries, Box 734, Cleveland OH 44107.



THE BIG PICTURE

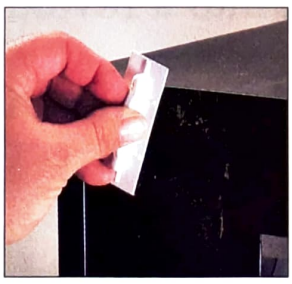
E-Z Reader magnifies printed material 10, 20, or 30 times so the visually impaired can read everything from bills to medicine bottles. The hand-held camera slides across the print and displays a black and white image on a television or video monitor. Prices: $1,150 to $1,425, depending on magnification. E-Z Reader, 3920 Central Ave., St. Petersburg FL 33711.

MINI ZOOM 35

The Ricoh Shotmaster UltraZoom continues the trend toward miniaturization of lens/shutter cameras, packaging a 38-60mm zoom lens in an auto-everything model that weighs only eight ounces. A novel Super Night Mode makes two exposures on a single frame: a longer one for ambient light and a second flash exposure for the subject. Price: $249.

ANTI-GLUE

Packets of Adhesive Remover & Surface Cleaner dissolve the gummy residue left behind by price tags and tape. Place a pad on the sticky surface and squeeze the handle. A package of two costs approximately $3. 3M Do-It-Yourself Division, Box 33053, St. Paul MN 55133-3053.



SMOKE SCREEN

The Jalypso Smoke Filter emergency mask is filled with lightweight, oil-coated beads that trap particulates and prevent smoke inhalation, enabling the wearer to escape from a fire. An elastic strap holds the cloth-covered mask over your nose and mouth. Price: $30. Jalypso Marketing, 1500 Commerce St., Corona CA 91720.

FLYWHEEL TROLLEY

When this electric trolley brakes, it spins a 400-pound flywheel that stores excess kinetic energy. When the trolley accelerates, the flywheel releases the energy so 25 percent less power is needed from the overhead cables. The flywheel is located next to the right front wheel. The 58-foot-long trolley is made by Neoplan. Gottlob Auwarter GmbH & Co., Box 810140, Vaihinger str 118-122, 7000 Stuttgart 80, Germany.

HALF-PINT PRINTER

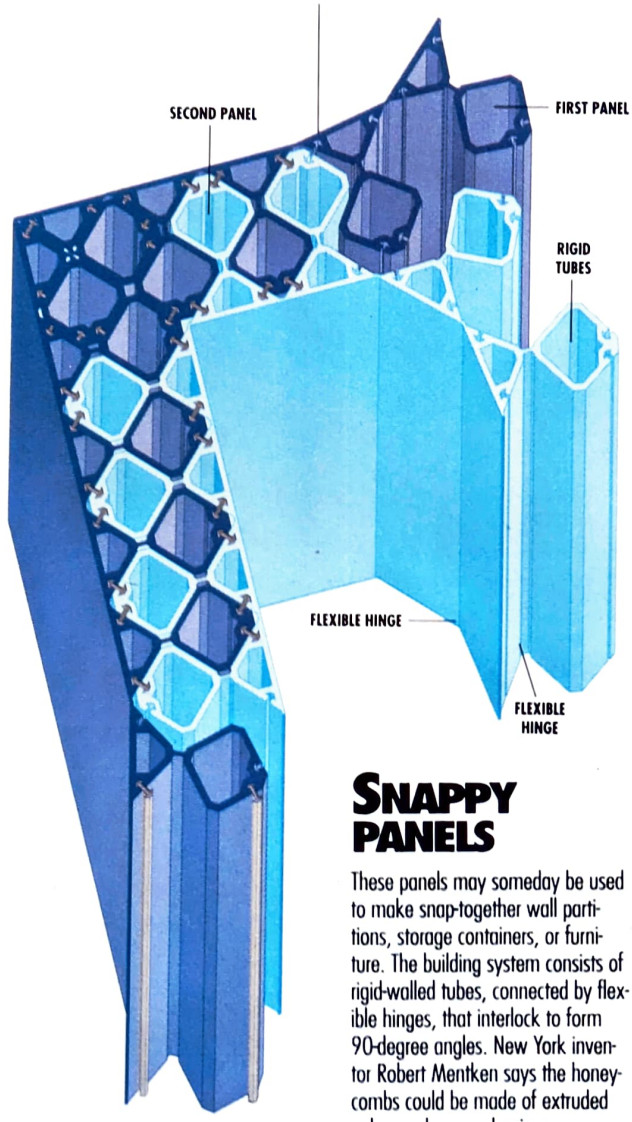
Kodak's Diconix 701 ink-jet printer is smaller than a sheet of standard paper and weighs just 5.9 pounds with a battery. It features letter-quality portrait and landscape printing at two pages per minute and a built-in feeder that holds 30 sheets of paper. Price: $549. Eastman Kodak Co., Printer Products Division, 343 State St., Rochester NY 14653.

LAP COUNTER

SportCount, a lap counter worn on your index finger, displays average and best lap speeds, elapsed time, and number of laps (up to 99). The waterproof device, now in prototype, will cost $30. SportCount, 8862 Monard Dr., Silver Spring MD 20910.

NIGHT LIGHT

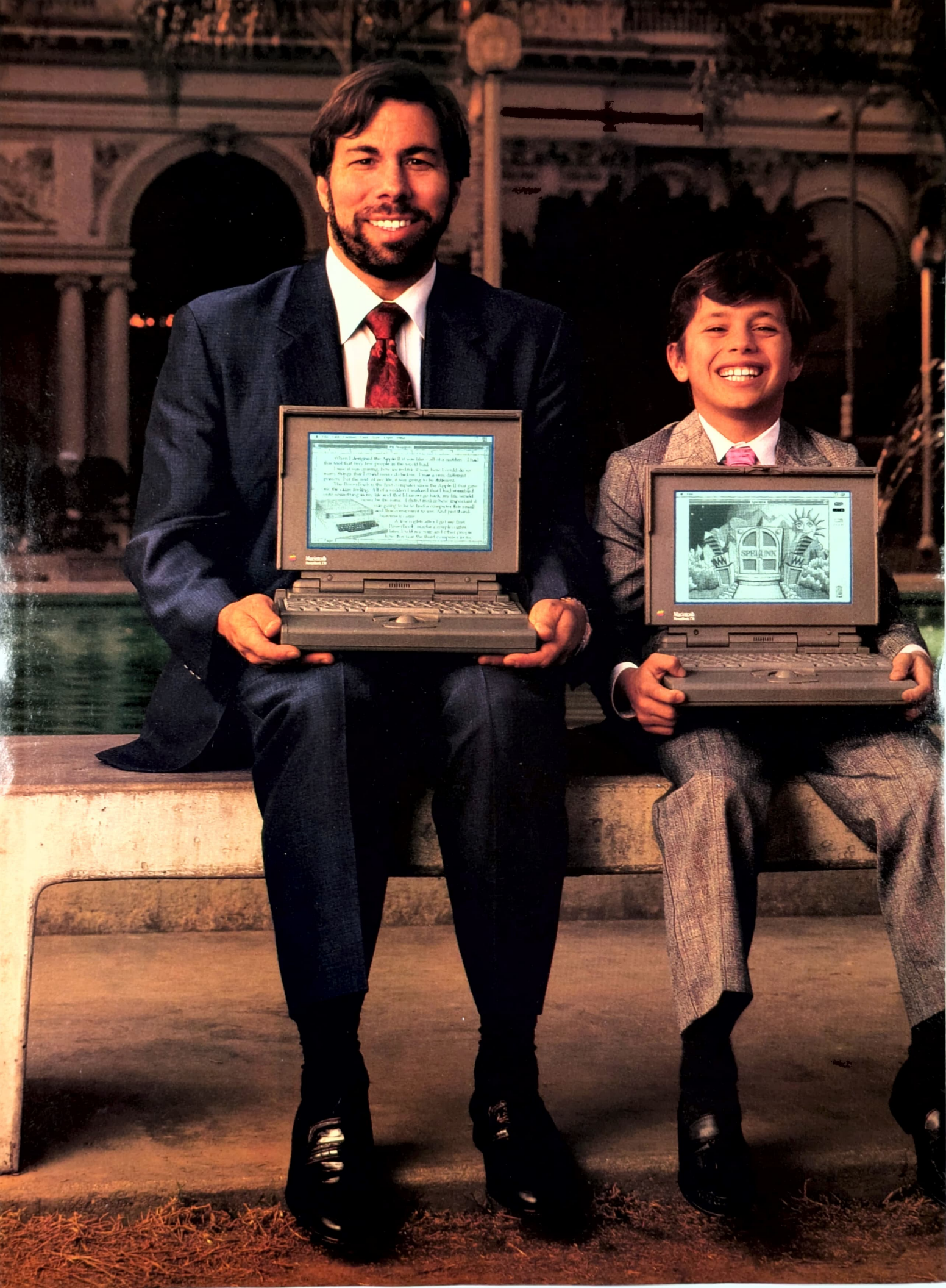
The E-On flashlight has three light-emitting diodes—two amber and one red—that produce enough light to read a map at night without interfering with your night vision. The $25 light indicates when the nine-volt battery needs replacing. GDI, 8948 S.W. Barbur Blvd., Suite 150, Portland OR 97219.



STEVE STANKIEWICZ

SNAPPY PANELS

These panels may someday be used to make snap-together wall partitions, storage containers, or furniture. The building system consists of rigid-walled tubes, connected by flexible hinges, that interlock to form 90-degree angles. New York inventor Robert Mentken says the honeycombs could be made of extruded polypropylene or aluminum.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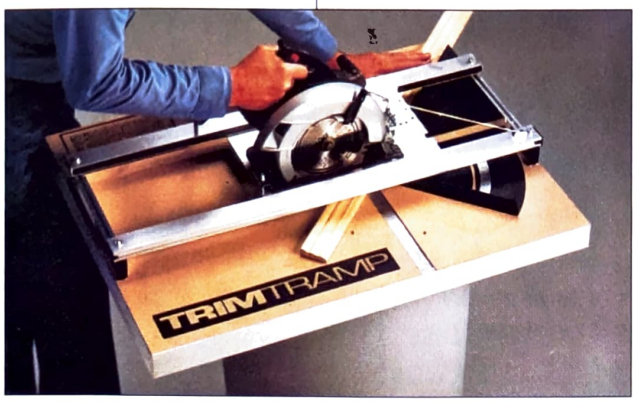
For the name of your nearest authorized Apple reseller, call 800-446-3000 ext. 700. To run MS-DOS, all you need is a program like SoftPC and an Apple SuperDrive disk drive (it's standard on the PowerBook 140/170. An optional external version is available for the PowerBook 100.) **Comparisons are based on a 1991 independent research study conducted by Ingram Laboratories that tested a variety of personal computers running applications available for both the Macintosh and Microsoft Windows 3.0 environments. © 1992 Apple Computer Inc. Apple, the Apple logo, AppleTalk, Macintosh and "The power to be your best." are registered trademarks, and PowerBook and SuperDrive are trademarks of Apple Computer Inc. MS-DOS is a registered trademark and Windows is a trademark of Microsoft Corporation. SoftPC is a registered trademark of Insignia Solutions Inc. InfoWorld is a trademark of InfoWorld. This ad was created using Macintosh computers.

WHAT'S NEW

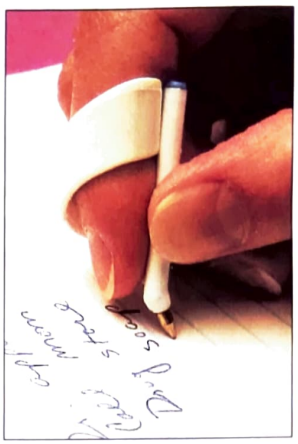


NEW SKILLS FOR OLD SAWS

The Trimtramp table converts a portable circular saw into a sliding compound miter saw. The table has permanent left- and right-hand 45-degree fences for miter and bevel cuts, plus a crosscut fence that retracts when not in use. Cuts are made by drawing the saw backward on the rails. The 21-pound table costs $130. Trimtramp, 151 Carlingview Dr., Etobicoke, Ontario M9W 5S4, Canada.

EASY WRITER

Designed for people who find traditional writing implements difficult or uncomfortable to hold, this pliant plastic pen slips on a finger like a thimble. It is available in five sizes and holds about two-thirds as much ink as a standard-size pen. Swereco Rehab AB, Box 6014, S-191 06 Sollentuna Sweden.



FLYING CHAIR

A new twist on conventional water skis, the Air Chair rides above the water like a hydrofoil so you don't lose your balance over rough wakes and waves. Price: $745. RBM Inc., 665 S. Lincoln Ave., San Bernardino CA 92408.

VERSATILE VIDEO

With its ability to capture images directly from a variety of sources, edit them, and feed them to a monitor or printer, Canon's RC-570 Still Video Camera can be the heart of a flexible business presentation system. Its features include a 3x power zoom lens, infrared autofocus, built-in flash, and four shooting speeds. Price: $3,400, with all equipment needed for recording and playback.

LANE SHIFTER

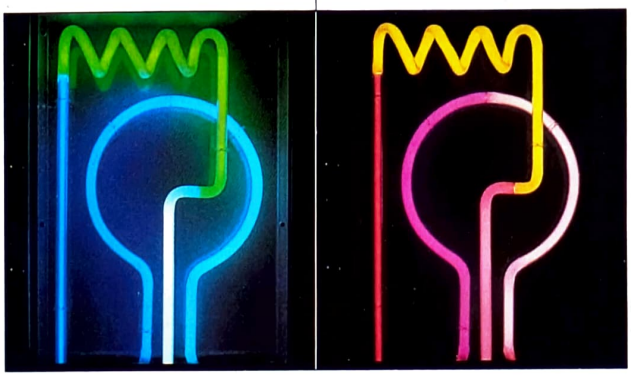
To reduce rush-hour congestion, the Quickchange Moveable Barrier system creates an extra lane for the busier direction. A self-propelled vehicle picks up each 1,500-pound barrier by its T-shaped ledge, pulls it under the carriage on a conveyor, then sets it down in the new position. A signal-emitting cable beneath the pavement steers the vehicle. The system also reroutes traffic during road construction, as shown here in New York City. Barrier Systems, Box 125, Sausalito CA 94966-0125.

RESTYLED PICKUP

The 1993 Nissan Truck features styling changes inside and out, including a revised instrument layout, audio system, and a new front bumper and grille. It's also one of the first Nissan products to use the environmentally friendly coolant R-134a in its air conditioner. Nissan plans CFC-free air conditioners for its entire product line by 1994.

HIGH SOUND

Jamo's Oriel four-way bass-reflex speakers with twin-coupled eight-inch woofers combine elegant sound with style. Designed with black glass and cherry wood trim, the speakers stand almost six feet high. Price: $9,000 a pair. Jamo Hi-Fi USA, 425 Huehl Rd. #8, Northbrook IL 60062.



NEON CHAMELEON

By varying the electrical current, KISC's MultiNeon system produces as many as five color gradations in a single neon tube. The system consists of a $650 transformer and $480 controller. The tubes require mercury vapor, not the argon gas traditionally used. Kimoto International Sign Concept, 4173 Rousseau Lane, Palos Verdes Peninsula CA 90274.

LUXURY LINER

The all-new body on Cadillac's 1993 Brougham is 4.3 inches longer than last year's model—making it, at 225.3 inches, the longest regular-production car built in America. Both the windshield and back window have a flush glass design.

RX FOR MUSCLES

Based on the ancient Japanese art of shiatsu massage, Vitec's hand-held Pressure Point Massager incorporates two Teflon-coated massage domes that counter-rotate in one-inch orbits to knead knotted muscles anywhere on the body. Price: $175. Vitec, 4371 Charlotte Hwy., Suite 7, Lake Wylie SC 29710.

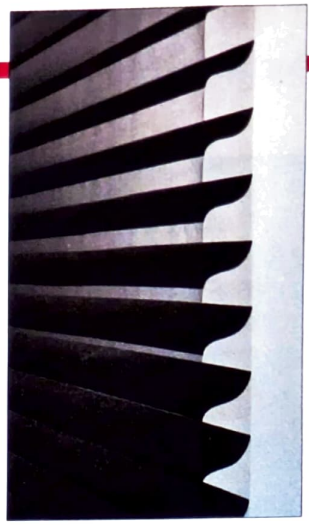
SWIVEL LIGHT

FlashMate grasps any size flashlight. It rotates 360 degrees horizontally and pivots 90 degrees vertically so the light can be pointed in any direction. Its built-in magnet or spring-loaded clamp secures the $13 holder. Innovation, Box 117700, Burlingame CA 94011.

WHAT'S NEW

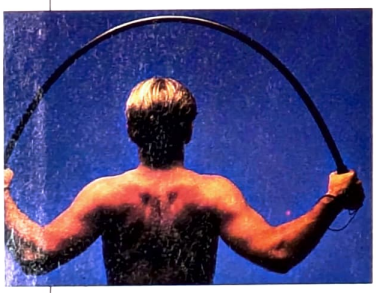
WIDE-ANGLE SECURITY

Thanks to a 190-degree-angle sensor, the Reflex Professional Motion Sensor Light Control SL-5313 detects any warm moving object in a 8,100-square-foot area. The $40 light has a pre-wired, bright quartz halogen light that can be programmed to remain lit from 1 to 20 minutes when the sensor is triggered. Heath Zenith, 455 Riverview Dr., Benton Harbor MI 49022.



WINDOW DRESSING

Silhouette window shadings combine the softness of curtains, the insulative properties of shades, and the privacy and light control of blinds. They are available in 30 colors. Price: $300 for a standard-size window. Hunter Douglas Window Fashions, One Duette Way, Broomfield CO 80020.

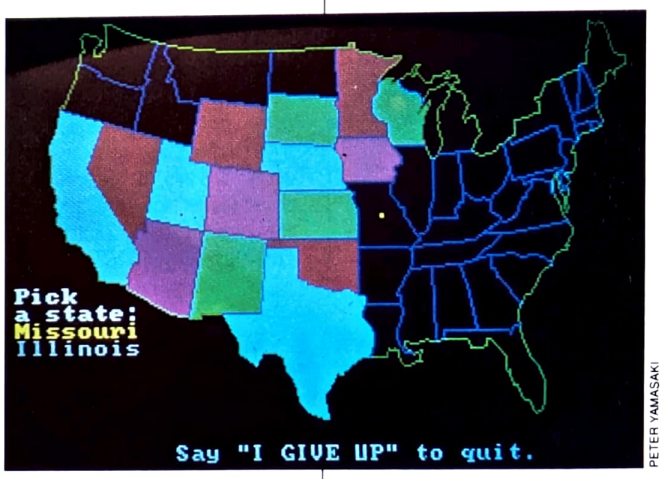


PORTA-GYM

The Stealth Gym Flexerciser exercise rod generates between 20 and 70 pounds of resistance when you bend it into a U-shape. The five-foot-long, two-pound rod is said to be three times stronger than steel and can be used to work every large muscle group. Price: $50. Exercise Products, 12377 Merit Dr., Suite 1140, LB #90, Dallas TX 75251.

MUSEUM WARE

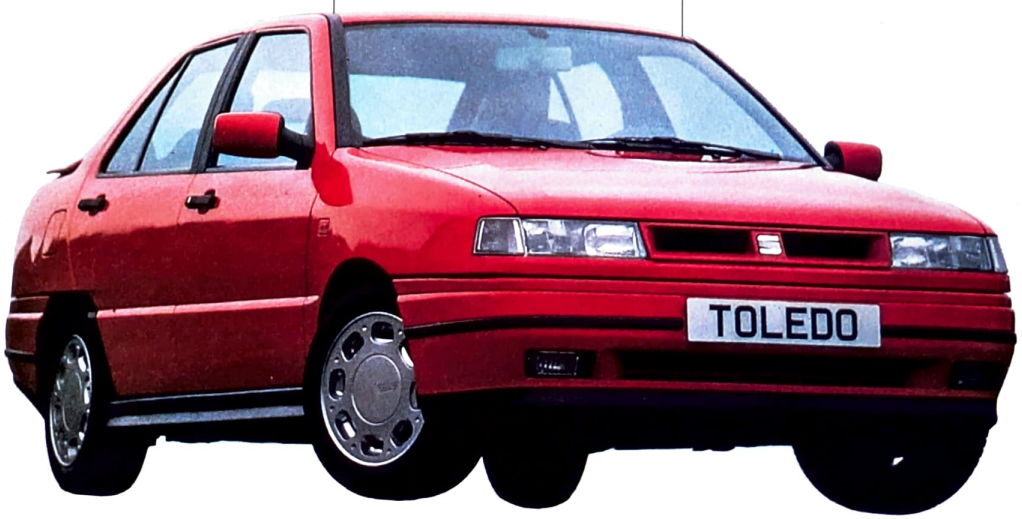
The Computer Museum now offers eight of its interactive exhibits as Exhibit Kit Programs for personal computers. The Color the States kit (shown) illustrates voice recognition; a map of the United States is colored using speech commands. The kits cost from $875 to $5,400 and come with educational materials and layout suggestions; some include additional hardware. The Computer Museum, 300 Congress St., Boston MA 02210.



PETER YAMASAKI

MIXED BREED

Madrid-based Seat SA, part of Volkswagen, unveils the Toledo with hopes of entering the U.S. market. Based on the Jetta floor plan, the car blends German engineering and Spanish styling. It's offered with four VW gas engines from 75 to 136 hp, plus a 68-hp diesel. Power steering and a tilt/slide sunroof are standard; antilock brakes come on the top-of-the-line models.



A SHARPER IMAGE

Sony's trio of advanced TVs will combine a digitally controlled chassis and an improved flat Super Trinitron tube for sharper picture quality. An on-screen menu will let you select categories, such as sports or movies; optimum audio and video adjustments will be set automatically, depending on the program selection. The 32-inch KV-32XBR95S (right) costs $2,599 and should be available this fall.

COMING FULL CIRCUIT

Computer circuit boards pose a difficult disposal problem because they are nonbiodegradable. Swiss artist Luca Bonetti solves that by using the boards as coverings for his Tecnotes line of memo books, binders, and clipboards. Prices: about $25 to $75. Tecnotes, Box 258, Wainscott NY 11975.

TENNIS BALL BELT

Hip Clip keeps spare tennis balls out of your pockets. The plastic caddy, which comes in a variety of colors, straps to your waist and stores up to three balls. Price: approximately $7. T & K Tennis Ball Clip, Box 613, Panguitch UT 84759.

HIGH-TECH PANTRY

Push a button on the Kitchen Carousel shelving system and dishes or canned goods revolve into view. The electronic system is about the size of a refrigerator and provides approximately 30 square feet of storage. The Carousel will be available in December for about $5,500. White Home Products, 2401 Lake Park Dr., Atlanta GA 30080.

MARINE PHONES

Navico's marine radio telephones are waterproof, shock-resistant, and can withstand a rapid change in temperature of up to 100°F. Made in three models, the Axis hand-held transceivers cover the 155-to-164-megahertz range, have five-watt output power, and weigh 1.3 pounds. Price: approximately $700 each. Navico Inc., 7411 114th Ave. N., Suite 310, Largo FL 34643.

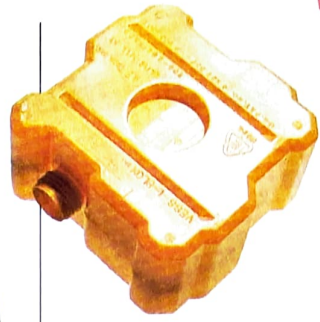
WHAT'S NEW

NATURAL-GAS HOT ROD

The first competition drag car ever powered by natural gas, the 700-hp, clean-burning Natural Gasser does a quarter-mile in as little as 9.38 seconds, reaching 155 mph. Designed and driven by Joe Mezquita of East Ohio Gas, the Gasser has attained 45th place in the National Hot Rod Association "super gas" class.

LOCKING BLOCKS

Vess-L-Blox high-density polyethylene containers can hold beverages, soap powder, or even antifreeze. Here's the plus: Once empty, the interlocking containers can be used as building blocks. The FDA-approved forms will be available to manufacturers in half-gallon and gallon sizes. Prices have not been finalized. Advanced Building Technologies, Box 674, Olive Hill KY 41164.

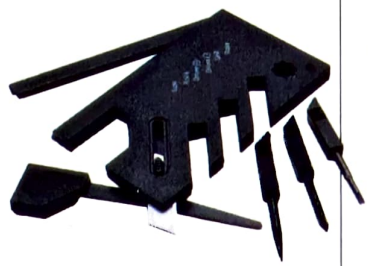


VEGETABLE OIL

Bioplus chain-saw lubricant is vegetable-based rather than petroleum-based so it won't harm microorganisms or plants. In addition, it won't produce the heavy deposits that form when synthetic oils combine with sawdust and tree sap. A one-liter container costs $5.50. Stihl Inc., Box 2015, Virginia Beach VA 23452.

THREE-WHEELED TRANSPORT

Daihatsu's minimal bid to meet California's upcoming zero-emissions law is the three-wheeled electric BC-7. Only 6.5 feet long and nearly as tall, the single seater is powered by a five-kilowatt (seven-hp) motor with a top speed of 28 mph. Its range is 60 miles on lead-acid batteries or 110 miles with a nickel-zinc alternative. Could the Japanese have an eye on the golf-cart market?

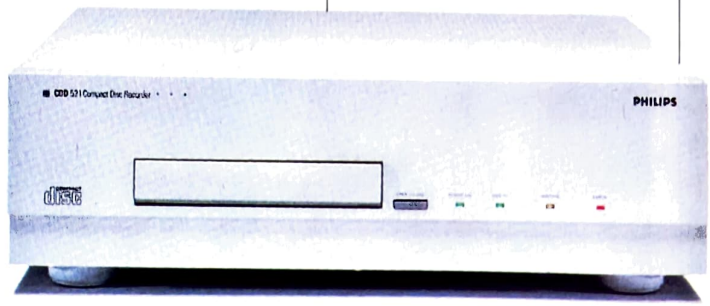


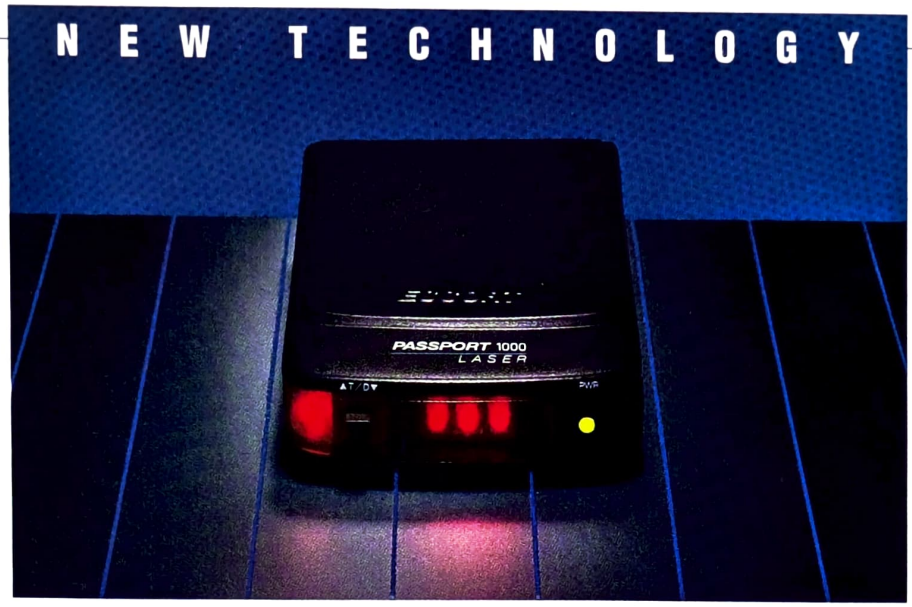
TINY TOOLS

A knife, ruler, saw, bradawl, two screwdrivers, and a wrench socket fit inside this credit-card-size unit. Price: $10. Science Museum Brainwaves, Harrington Dock, Liverpool X, L70 1AX, England.

CD RECORDER

The CDD 521 desktop recorder from Philips Consumer Electronics captures data on non-erasable discs in CD-ROM (XA), Photo-CD, CD-I, and standard audio formats. The $5,995 machine enables companies to copy limited numbers of 600-megabyte discs. At more than 300 kilobytes per second, recording and playback speed is twice that of other systems. Average access time is one second.





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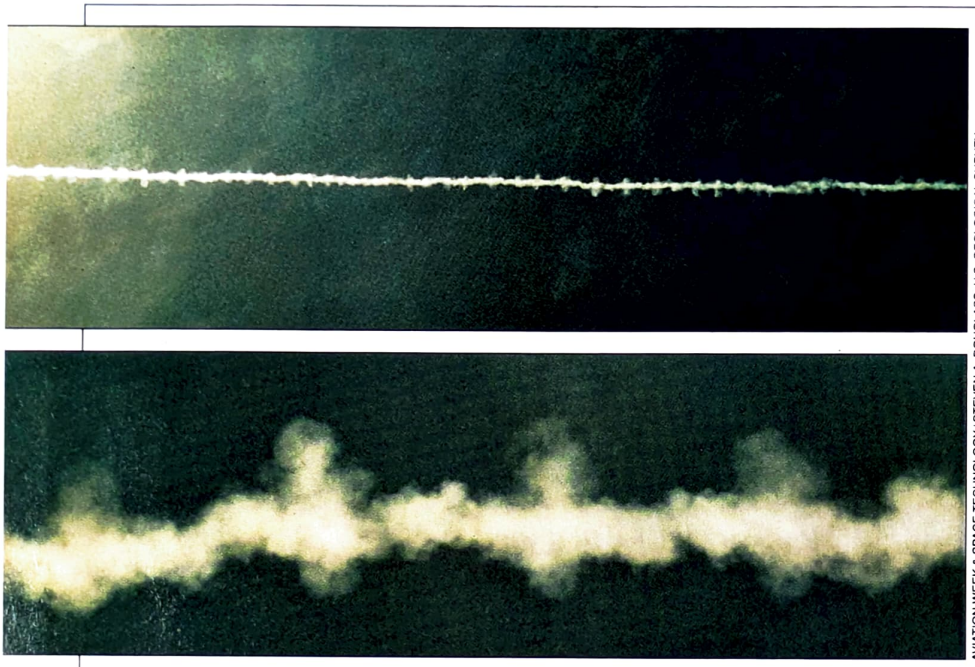
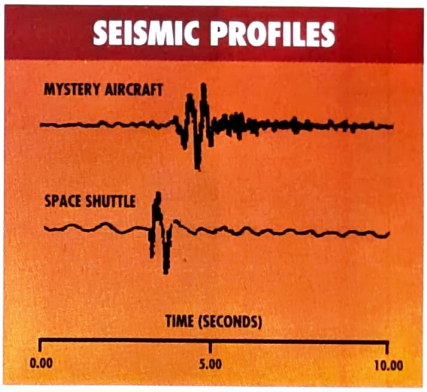




AVIATION WEEK & SPACE TECHNOLOGY / STEVEN A. DOUGLASS: U.S. GEOLOGICAL SURVEY

These photos (left) of the unique, pulsing exhaust contrail of an aircraft flying at high altitude over Amarillo, Texas, were taken on March 23. The plane passed out of sight before the photographer could locate it. U.S. Geological Survey seismic profiles (above) show the space shuttle's distinctive N-shaped sonic-boom waveform and the mystery plane's more complex signature.

What hypersonic airplane?

Something very strange is flying around at terrific speeds. Although no one has managed to photograph the craft itself, its radar image, unique exhaust contrail, engine sound, and sonic boom have all been characterized in multiple reports by observers in the Western United States and Great Britain. Yet questions directed to the prime suspect in mystery-plane cases—the U.S. Air Force—yield only denials of any knowledge.

The aircraft betraying its shadowy presence may be a high-altitude hypersonic spy plane code-named "Aurora" that's presumed to have replaced the retired SR-71 Blackbird ["Revealed! Mach 5 Spy Plane," Nov. '88]. On five occasions since June 1991, the U.S. Geological Survey's extensive network of earthquake-monitoring seismographs in Southern California has recorded window-rattling sonic booms produced by an airplane traveling northeast at several times the speed of sound.

The booms have all occurred on Thursdays at about 7 a.m., says U.S. Geological Survey seismologist James J. Mori at the California Institute of Technology in Pasadena. "We call them airquakes," he says. "This mystery plane has a distinctly different sonic-boom waveform than other large, supersonic aircraft like the space shuttle and the SR-71. We track it because people have been calling us wanting to know if there's been an earthquake."

Many observers in several states have reported hearing very loud, deep rumbling and pulsating sounds coming from an aircraft moving at high speed. An aircraft emitting these sounds was spotted this past February taking off at night from Beale Air Force Base near Sacramento, Calif. Its propulsion system may be a pulse detonation wave engine—a known type that develops thrust in intermittent bursts, rather than continuously—according to reports in the trade journal *Aviation Week & Space Technology*.

Bill Sweetman, an expert on classified "black" military programs, suggests in *Jane's Defense Weekly* that the aircraft may be capable of reaching Mach 6 (4,000 mph) burning liquid methane or hydrogen fuel. He believes the plane is returning from hypersonic (greater than Mach 5) flights over the Pacific Ocean and decelerating over the Los Angeles area as it heads northeast for a landing at the highly classified flight test base at Groom Lake, Nev.

Sweetman reports that a Royal Air Force air traffic controller tracked an aircraft leaving the remote NATO-RAF base at Machrihanish in western Scotland last November at a speed of Mach 3. No acknowledged aircraft capable of such speed is based there.

Call it Aurora, the mystery plane, or whatever. The ultrafast, groundshaking high-flyer may be one of the latest in the long line of exotic aircraft that have resulted from Lockheed Corp.'s fabled Skunk Works. Financial analysts note that the company's budget and work force can only be fully accounted for by one or more substantial black programs secretly funded by the Pentagon—and perhaps the intelligence services.—*Stuart F. Brown*

Gloves for astronauts

Nobody likes cold hands, says Peter E. Glaser—least of all, astronauts in the frigid vacuum of space. "Working in the pressurized space suits is hard," explains Glaser, vice president of space operations at Arthur D. Little Inc. of Cambridge, Mass. During rest periods, astronauts' hands get cold because their gloves can't be made too bulky. "Too much insulation hinders finger movement," says Glaser.

Now researchers at Arthur D. Little, working under the President's Space Exploration Initiative, have a potential solution: gloves that can store heat when hands are warm and release it when the temperature drops.

The key is packets of a gallium alloy inside the glove. The packets are located atop the hand; a fluid pumped over them distributes heat evenly. "The al-

loy starts as a solid," says Glaser. As astronauts work, their bodies and hands get warmer, melting the alloy. "As it melts, it stores heat," he says. "When the astronauts stop working, the storage material will give off heat."

Researchers have demonstrated a prototype glove to NASA. Sensors in an instrumented mannequin hand monitored glove performance during cold-chamber testing. The results were favorable, says Glaser, but it may take several years to develop the optimum design for the glove.

Others could benefit from the technology. "It has many possible applications, such as ski or hunting gloves," says Glaser. Officials from Arthur D. Little are discussing the concept with interested manufacturers.

It's difficult to determine how much the heat-storage material would add to the cost of a glove. Says Glaser: "An astronaut's glove is in the hundred-thousand-dollar range. So the cost of adding heat-storage material would be insignificant." A ski glove with the material might cost significantly more than an ordinary ski glove, he says, "but then I remember when my tennis shoes were just $5 or $10." —*Mariette DiChristina*

Buckymembranes

Scientists at Sandia National Laboratories in Albuquerque, N.M., have discovered yet another interesting property of the soccer-ball-shaped carbon molecules known as fullerenes or buckyballs: In a buckyball crystal, the tiny spaces between molecules can trap gases. This property could make buckyballs useful in gas storage or separation devices.

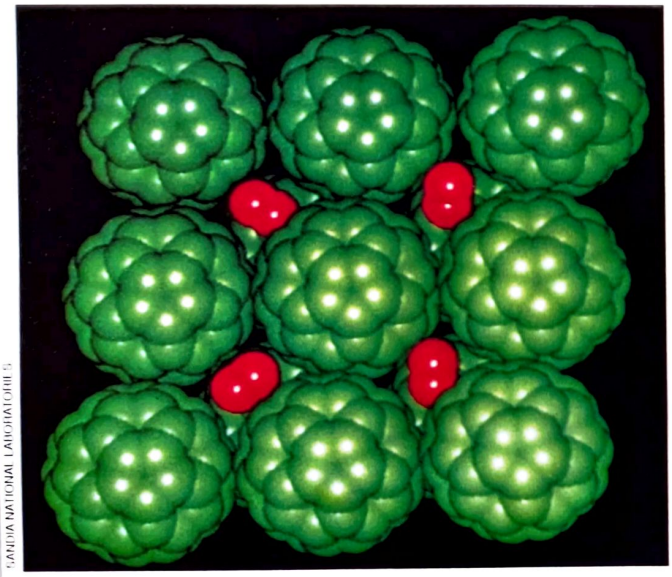
While studying the purity of a buckyball crystal, researchers led by chemist Roger A. Assink discovered evidence of oxygen contamination. They traced the contamination to oxygen molecules that had wandered into a few of the spaces between buckyball molecules in the crystal lattice. While some scientists have intentionally introduced metal atoms into these spaces, no one knew that gases might migrate into the spaces of their own accord.

Under normal conditions, only about 1 percent of the spaces are filled with gas molecules, says Assink. "To get a lot of gas molecules in, it takes a lot of pressure." At one kilobar of pressure (about 15,000 pounds per square inch), more than half of the sites can be filled with gas molecules.

To store gases, Assink says the gases would probably need to be kept under moderate pressure to prevent leakage.

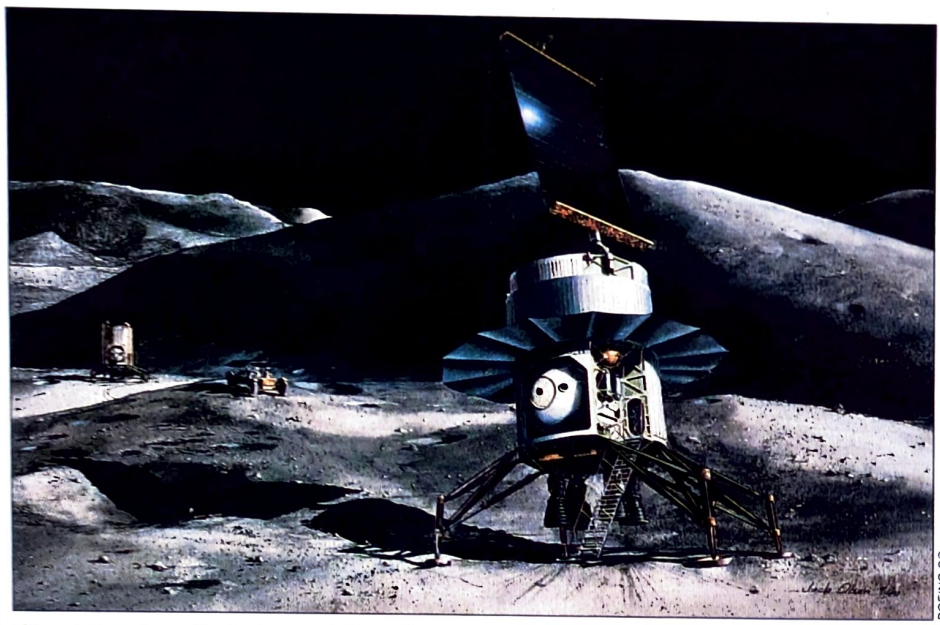
"Perhaps a more interesting application is to separate gases," he says. Hydrogen, for example, diffuses into a buckyball lattice more than 300 times faster than oxygen. And methane molecules are too large to get into the lattice at all. "You can imagine making a membrane where hydrogen or oxygen will diffuse through, but not methane," says Assink.

Such a membrane might be useful for purifying natural gas, which is often contaminated with nitrogen. Nitrogen molecules are about the same size as oxygen molecules. Assink's group is now planning to construct a buckyball membrane and test the feasibility of using it as a gas separation device.



SANDIA NATIONAL LABORATORIES

Buckyball crystals might be useful for storing or separating gases. Computer graphics show a crystal in which oxygen molecules (red) are trapped in the spaces between buckyball molecules (green).



BOEING CO

This painting shows Boeing's concept for a "lunar campsite," a temporary structure that doubles as an experiment center and construction facility. Upon landing, astronauts drive to the campsite in a rover.

Camping on the moon

When astronauts return to the moon, they won't pitch tents, swat mosquitoes, or roast marshmallows. But they may stay in a "lunar campsite" while they explore the moon's surface, set up science experiments, and begin constructing a permanent outpost.

A fully assembled campsite could be launched from Earth as early as 2000, says Carl Case, exploration systems manager at Boeing Co.'s advanced civil space systems division in Huntsville, Ala. The campsite would be equipped with a habitat module, an airlock, a lander stage, thermal radiators, solar arrays, a life-support system, and communications gear. Boeing is developing some of the same components for the space station Freedom.

"We want something that doesn't require a lot of setup time, so that astronauts can spend most of their time exploring," says Case.

Alighting at a site mapped out by

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earlier robotic missions, the campsite would deploy its solar array and stairway. A crew of four would arrive later in an Earth-moon transfer vehicle, then drive to the campsite in a lunar rover. The crew would stay in the campsite for up to 45 days, then return to the transfer vehicle for the trip back to Earth.

"The campsite could be used by several crews in succession as a construction facility for the development of a permanent lunar base or as a remote science facility," says Case.

No bust for big bang

"What we have found is evidence for the birth of the universe and its early revolution."

The speaker, astrophysicist George Smoot of the Lawrence Berkeley Laboratory in California, was presenting his team's riveting findings at a meeting of the American Physical Society in April. After a year of scrupulously checking and rechecking data from the Cosmic Background Explorer (COBE) satellite, the Berkeley group announced they had found minuscule temperature variations—measured in hundred-thousandths of a degree—in the cold radiation that pervades the universe.

Known as the three-degree background (actually 2.7°K), this radiation is the fingerprint of the hypothesized big bang, the primeval explosion from which the universe burst forth ["Searching for the Cosmic Connection," April '91].

The discovery of these temperature (and therefore density) variations has been long awaited by increasingly despairing theoreticians. All previous COBE measurements showed a perfectly smooth, uniform background radiation. That is consistent with the notion of radiation expanding outward from the big bang. But the present universe is anything but uniform; it is spangled with clumps of matter in the form of galaxies and galactic clusters, separated by immense voids. They must have condensed, cosmologists reasoned, from some kind of discontinuity in the background.

The new COBE results support that discontinuity. As Smoot said, "These small variations are the imprints of tiny ripples in the fabric of space-time put there by the primeval explosion process. Over billions of years, the smaller of these ripples developed into the structures of the universe."

The discovery does not, as some eager headline writers assumed, prove the validity of the big bang hypothesis. And it does not explain how the ripples came to be. But it does clear a land mine from the long road to understanding the birth and life of the universe.—*Arthur Fisher*

TABLETOP ARTILLERY

Researchers at Los Alamos National Laboratory in New Mexico are developing a revolutionary gun that uses high voltage to fire projectiles.

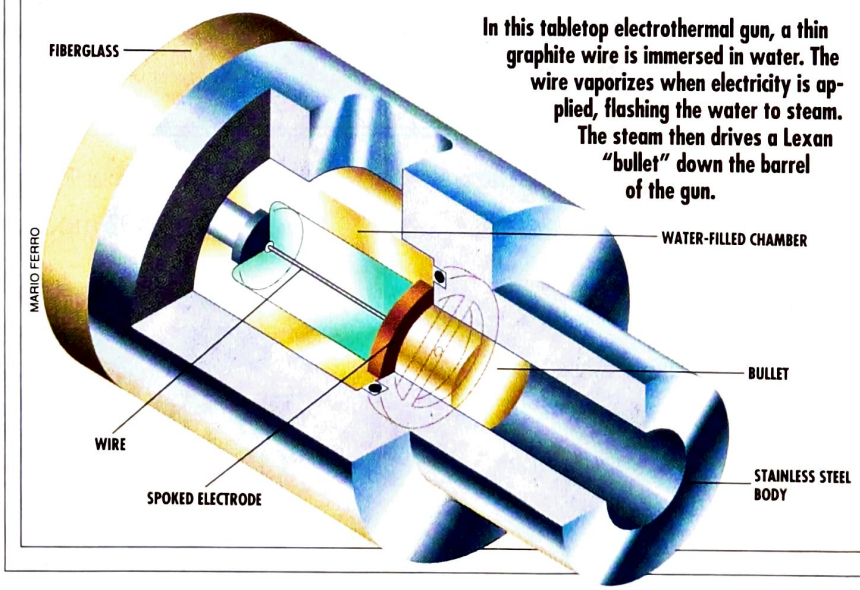
The sudden blast and jolting acceleration of conventional artillery propellants is incompatible with the sophisticated electronics that will be used in "smart" munitions of the future. Electrothermal propulsion, however, could provide a "soft launch" for guided shells.

In an electrothermal gun, the burn can be precisely controlled by manipulating the applied voltage. A controlled burn not only simplifies the design requirements for projectiles, but also extracts more kinetic energy from the propellant. The result: higher muzzle velocities.

The Los Alamos mini-cannon uses 4,000 volts of electricity to zap a thin graphite wire surrounded by a few tablespoons of water. The wire vaporizes to a 21,000°F plasma, turning the water into a ball of steam that drives the projectile. The gun develops a chamber pressure of 20,000 pounds per square inch, and with an ear-piercing bang it shoots a thumb-size Lexan "bullet" down a four-inch barrel. Future guns would use a chemical propellant rather than water.

According to project leader Harold Davis of Los Alamos's High-Energy Density Physics Group, full-scale electrothermal guns have behaved unpredictably in tests. "We decided to build a laboratory device and do a little basic research to better understand the physics involved," he says. A variety of instruments monitor the performance of the tabletop "ET gun," as Davis calls it.

"We can X-ray the boundary between the plasma and the working fluid," Davis says. The pictures reveal an instability that develops at this boundary and may eventually suggest new designs to correct the problem.—*Ray Nelson*



In this tabletop electrothermal gun, a thin graphite wire is immersed in water. The wire vaporizes when electricity is applied, flashing the water to steam. The steam then drives a Lexan "bullet" down the barrel of the gun.

Hot exhibit

Most news coverage of global warming tends to be simplistic, especially on television. It's such a complex subject, with so many variables, that predicting just how much global warming will occur under what circumstances, in which geographic locations, and with what climatic and biological effects, has generated much heated controversy.

Thus it's a pleasure to recommend a new exhibit at the American Museum of Natural History in New York City. Entitled "Global Warming: Understanding the Forecast," the exhibit makes maximum use of interactive, intelligently designed displays to show the links between, say, past world temperature changes and the spacing of tree rings. One visually stunning item is a clear plastic model representing what present-day New York City would have looked like 20,000 years ago, in the middle of an ice age. Only a few of the city's tallest skyscrapers poke through the top of a massive glacier. Everything else is buried.

The exhibition makes no political statements and is careful to delineate the many uncertainties still surrounding global warming. It is a joint project of the museum and the Environmental Defense Fund. In 1993, the exhibition will travel to museums in Los Angeles; Washington, D.C.; Denver; and Pittsburgh.—*A. F.*

Propping up Pisa

A steel corset around its middle and counterweights at its feet may not add to the Leaning Tower of Pisa's medieval charms, but engineers hope that these measures will stabilize the historic structure.

The tower was "very near to collapse" earlier this year, according to Michele Jamiolkowski, an engineer from Turin Polytechnic who heads an international committee set up by the Italian government in 1990 to decide how to save the tower. The committee recommended the installation of cables and counterweights.

In May, workers began wrapping plastic-covered steel cables around the most fragile section of the tower, between the first and second levels. The marble facing there is badly cracked, and the large opening at the foot of the stairwell puts additional strain on the walls.

The counterweights—600 to 800 tons of lead ingots—are expected to be in place by the end of the year.

The tower was built in three phases, beginning in 1173, and has leaned almost from the start. It tilted first one way then another as construction progressed. But when the seventh story was completed around 1277, the tower pitched suddenly toward the south. Each year, it leans a bit farther in that direction—mainly because an unstable layer of clay soil beneath the tower is thicker on the south side than on the north.

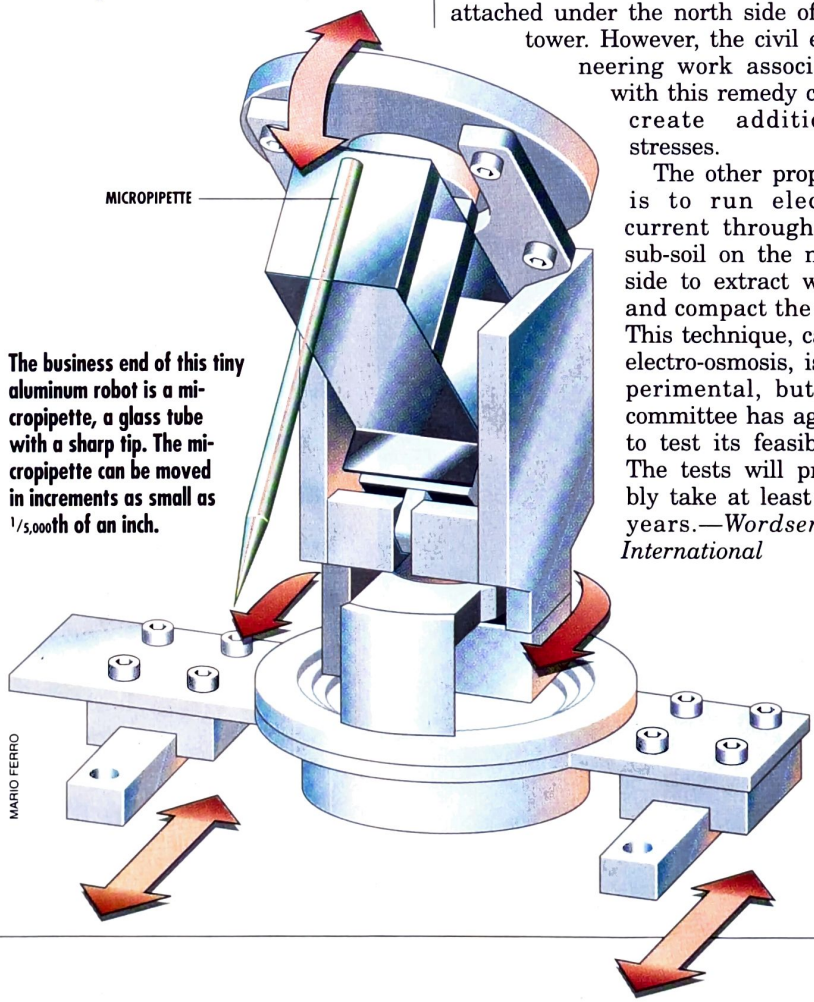
1178: CONSTRUCTION STOPPED AT 3.3 STORIES; RESUMED IN 1272
N
1173: CONSTRUCTION BEGINS
ABOUT 1177: 3RD STORY COMPLETED
500 SEC.
1,000 SEC.
1,500 SEC.
2,000 SEC.
ABOUT 1277: 6TH STORY COMPLETED
1278: 7TH STORY COMPLETED; INCLINATION = 7,320 SEC. SOUTH
1/360 DEGREE = 1 SECOND

STEVE STANKIEWICZ

This map shows the direction of lean at various points in the Tower of Pisa's history—determined by measuring the thickness of stones used to level the structure.

While the cables and counterweights temporarily hold up the tower, the committee must find a long-term solution. One proposal calls for ground anchors—steel tendons that would be attached under the north side of the tower. However, the civil engineering work associated with this remedy could create additional stresses.

The other proposal is to run electric current through the sub-soil on the north side to extract water and compact the soil. This technique, called electro-osmosis, is experimental, but the committee has agreed to test its feasibility. The tests will probably take at least four years.—*Wordservice International*



MARIO FERRO

The business end of this tiny aluminum robot is a micropipette, a glass tube with a sharp tip. The micropipette can be moved in increments as small as 1/5,000th of an inch.

Cell slicer

Researchers at the University of Washington have developed a mini-robot that could pave the way for a family of low-cost, easy-to-operate robots ideal for executing a wide range of precision tasks, ranging from microsurgery to microelectronics assembly.

The four-inch-tall prototype is capable of making computer-guided movements as small as 1/5,000th of an inch. With this level of precision, the device could be used to inject genetic material into a single living cell.

Micromanipulators that operate at the cellular level are already commercially available, but most use gears to control motion. The mini-robot built by electrical engineering professor Blake Hannaford has direct-drive joints, which allow the operator to feel resistance in the joystick that controls the machine.

Hannaford is currently developing software that will multiply the force being generated at the tip of the robot's micropipette, or glass probe, and transmit it back to the controller. Cutting a single cell in half might, for example, feel like cutting into an apple. Hannaford calls the concept "force-reflecting tele-operation."

The mini-robot was developed largely with existing technology. The controller is a standard Nintendo joystick, and the direct-drive joints are made from computer disk drives. As newer disk drives become available, Hannaford says he will be able to make the robot both smaller and more accurate. Commercialization, however, is still a year or two in the future.—*Todd Campbell* PS

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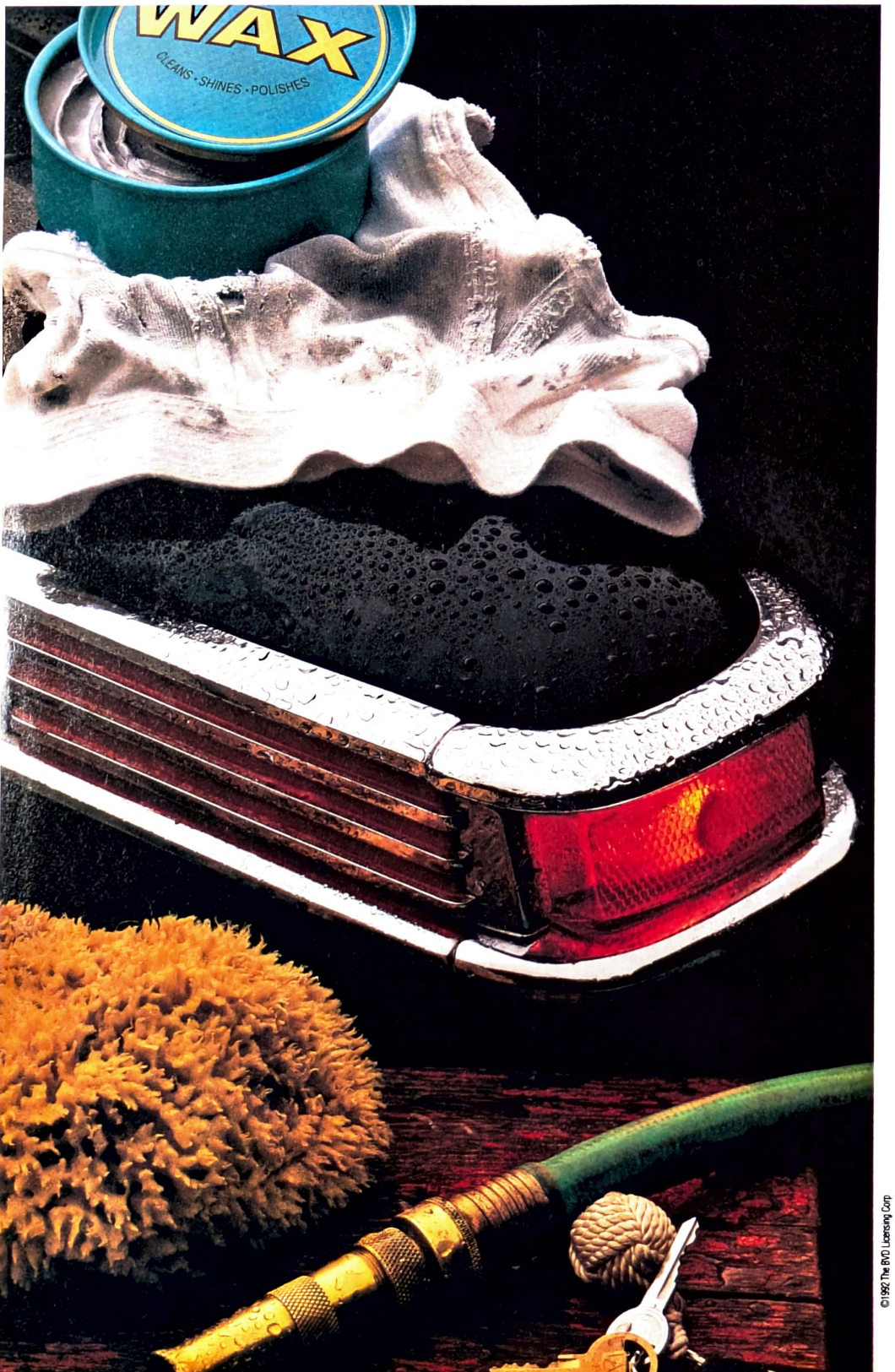

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Automotive Newsfront

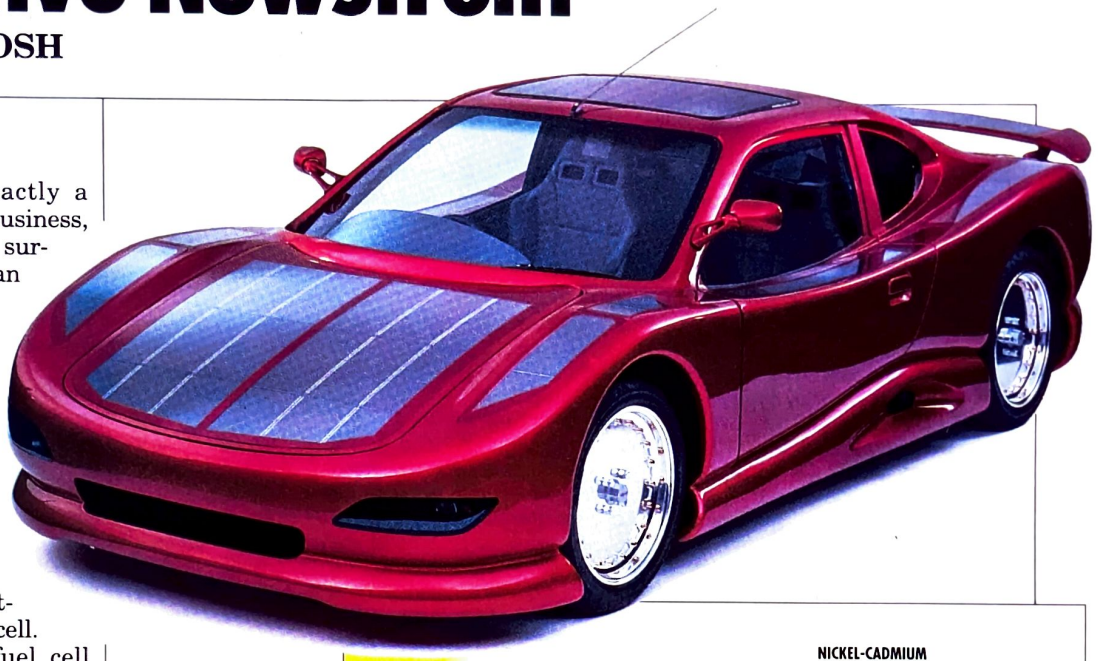
Edited by DAN McCOSH

Fuel cell on wheels

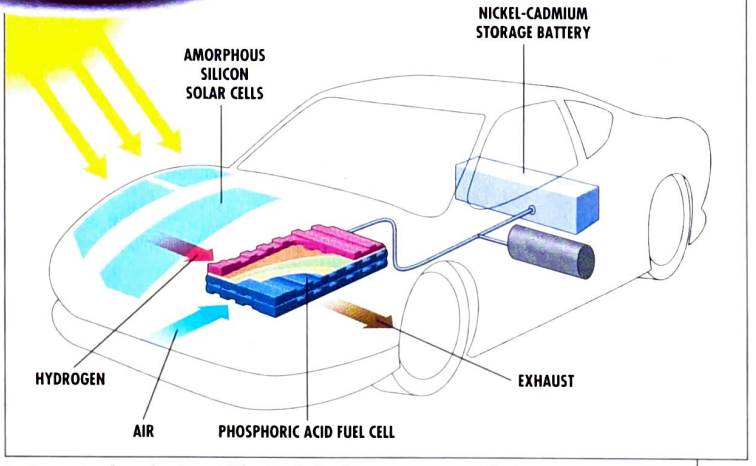
Sanyo Electric Co. isn't exactly a household name in the auto business, which makes it all the more surprising that it has developed an electric car partially powered by a fuel cell.

"We wanted to show just how far fuel cell technology has come," says Sanyo manager Akio Takeoka.

Actually, Sanyo's Mirai 1 ("mirai" means "future" in Japanese) shows off *three* energy-related technologies Sanyo prides itself on—solar cells and nickel-cadmium batteries in addition to the fuel cell. The solar cells and/or the fuel cell charge the batteries, which drive a brushless direct-current motor. It is the fuel cell, however, that has attracted most of the attention, drawing inquiries from many of the world's automobile manufacturers.



Sanyo's Mirai 1 solar hybrid car has solar cells over most of its body and a fuel cell mounted in the front. Both sources can be tapped to charge a nickel-cadmium battery pack in the rear of the car, which drives a brushless direct-current motor.



STEVE STANKIEWICZ

In Sanyo's phosphoric-acid fuel cell, hydrogen reacts with the oxygen in air to generate electricity. The hydrogen is supplied from a metal hydride cartridge. The hot air exhausted from the fuel cell is used to heat the metal hydride, which releases the hydrogen.

The car's top speed is just 62 mph, and it can only run for about two hours on a full charge. But continued charging by the solar panels and/or fuel cell extends that. The fuel cell generates electricity through a chemical reaction between hydrogen and air, a form of reverse hydrolysis; the only emissions are water vapor and air. Takeoka believes a fuel-cell-powered car would meet California's no-emissions requirements for autos, which are set to take effect in 1998.

Fuel cells are not likely to displace batteries completely. "It takes a fuel cell several minutes to come up to full power, and then it's better to run it at constant output," according to Takeoka. Sanyo envisions fuel cells being paired with batteries. The latter would provide the variable power needed for typical driving.

The potential advantage of a fuel cell could come from vastly reducing the number of batteries required and being able to recharge on the go. But to make this worthwhile, Sanyo faces the same problem as the battery makers—getting more power out of a smaller, lighter, less expensive fuel cell package. At present, the energy density of the fuel cell system, about 3.8 watts per pound, is less than one-third that of lead-acid batteries. Although it has a longer cycle life, the fuel cell costs far more. Takeoka admits that at the present state of the technology, there is little advantage in trading batteries for a fuel cell in electric cars.

Meanwhile the company has other applications much closer to commercialization. It is testing a golf cart powered by a combination of a fuel cell and nickel-cadmium batteries and may start selling a portable fuel cell generator this year.

The same phosphoric-acid fuel cell is used in all three applications. Hydrogen fuel is supplied in a metal-hydride cartridge based on the same principle as the hydrogen fuel tank Mazda showed off at last year's Tokyo Motor Show ["The Theme Is Green," Feb.]. The hydrogen is absorbed by a metal alloy within the cartridge, allowing the volatile gas to be stored in a stable, compressed state.—*Dennis Normile*

Buick looks ahead

A "fade to dark" sunroof; a car that adjusts itself to you before you get in; and enough horsepower to tempt even "mature" Buick drivers into youthful enthusiasm. These are just some of the ideas Buick installed in a series of concept cars testing new technology with an eye toward future production.

The sunroof varies light transmission via a concept called polymer dispersed liquid crystal (or PDLC) and is variable between clear and opaque, providing decreased "ultraviolet load" and improved passenger comfort. The PDLC also can be made in colors, with the glass matching the body paint until the driver varies the light transmission (though sunlight passing through is tinted the same color as the car's fin-

GEARING FOR THE INFINITE

BY STUART F. BROWN

Picture a housing full of gears with shafts emerging at both ends. Imagine twisting the input shaft with one hand while grasping the output shaft with the other hand. Now ponder this mystery: Though all the gears are meshed—and there are no friction clutches or fluid couplings in the gear train—the output shaft stays stationary, and no torque is felt on the output side.

So where on earth did the motion go? Even a master clockmaker could get a little crazy bending his mind around the elusive interplay of movement inside the purely mechanical, infinitely variable (IVT) transmission developed by Epilogics Inc. in Los Gatos, Calif.

The IVT is the invention of Paul Pires, a soft-spoken mechanical designer who puzzled the complex mechanism out in his head before building a model of it—that worked. Pires's background is in designing equipment used in electronics manufacturing, which may account for his preference for thinking about mechanisms and describing them in the lingo of circuitry. "Dealing with things on a symbolic level helps me come up with the concept, then I backtrack through the hardware," he explains. "I think of an overrunning clutch as a diode, for instance."

In characteristically electronic metaphors, Pires offers this description of the IVT's workings: "We take a DC signal, turn it into an AC signal, rectify it, and sum it—but we do it mechanically."

Pires works out refinements to the IVT concept using a kinematic analysis computer program introduced recently by Rasna Corp. in nearby San Jose, Calif. Developed to help mechanical designers model the interrelationships between moving parts, the software predicts collisions and problems of fit without the heartbreak of destroying actual prototype components. The accompanying illustrations were generated on the Rasna system.

The ultimate dream of these transmission developers is licensing their designs to auto makers for production by the millions. Cars with engines optimized for steady-state operation at their most efficient speed could have fuel consumption and exhaust emissions reduced by as much as 30 percent, according to some estimates. But new devices like the IVT run up against the fact that auto makers already have transmissions they are happy with. The huge expense and risk of tooling up for a radically different design is unappealing to them in times of inexpensive fuel and relaxed government regulation.

As a result, it's possible that the first IVT-geared car to hit the pavement will do so at supra-legal speeds. An engineer with a major team active in several classes of motor racing (who insisted on anonymity) says they have concluded from computer simulations that a "shiftless" race car could turn lap times several seconds quicker than conventional machines, providing the IVT doesn't add appreciable weight—and race rules permit its use.

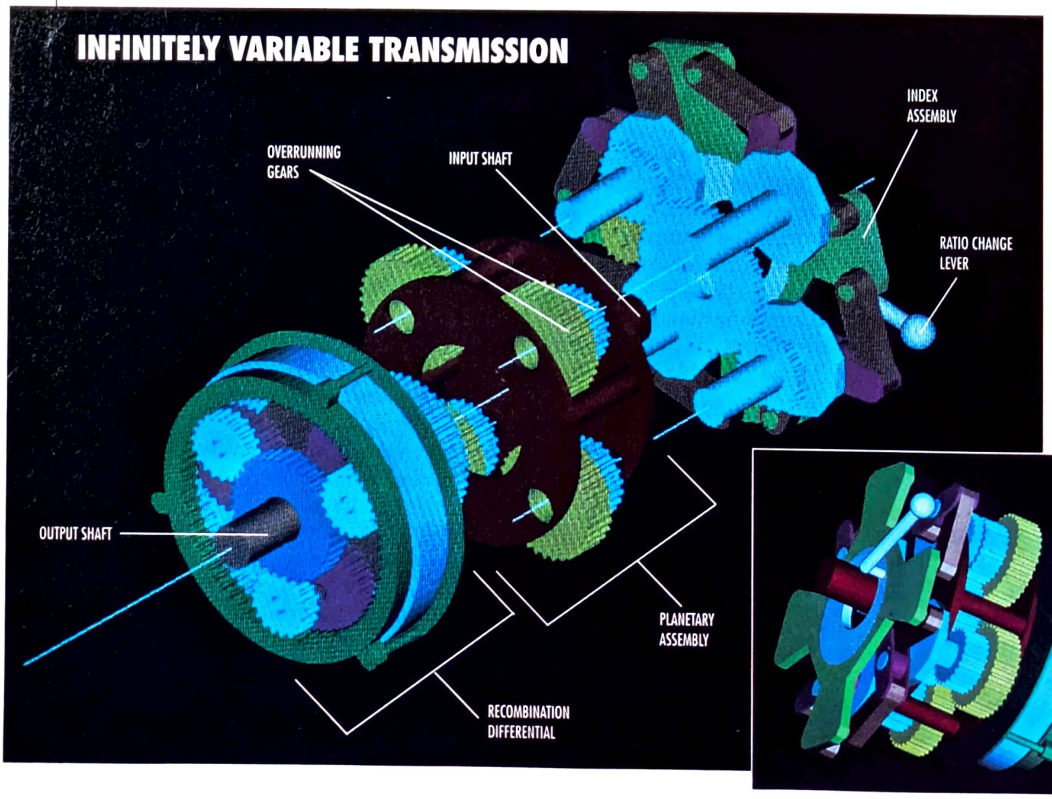
Among the beltless transmission's characteristics are its ability to handle large amounts of torque—a severe shortcoming of most continuously variable transmissions (CVTs)—and its lack of wear-prone sliding parts or fluid couplings that waste energy in the form of heat. It can shift steplessly from a "geared neutral" up to an input-to-output speed ratio of five to one.

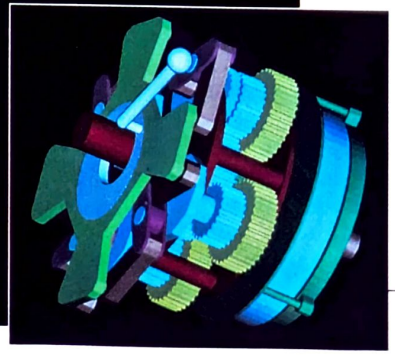
Together, these features have caught the attention of manufacturers of machinery ranging from truck transmissions to electricity generators. They see the infinitely variable transmission as a potential route to sizable fuel efficiency and performance improvements.

One of the first projects Epilogics tackled was building a large IVT into a heavy diesel tractor, which it demonstrated to a group of truck engineers. At present, though, it appears that the first commercial applications of the IVT may be relatively miniature in scale, according to Wayne Higashi, president of Epilogics. He says a maker of fan clutches for truck engines is showing customers a small prototype IVT that keeps the cooling fan running at a constant speed for better temperature control.

Another component maker, C.E. Niehoff & Co. of Evanston, Ill., wants to apply an IVT to the heavy-duty alternators it builds for transit buses and military vehicles. Currently, such vehicles require very large alternators in order to power accessories, such as air conditioners and electronic equipment, when the engine is idling. Niehoff is using the IVT to drive a much smaller alternator at a constant speed to save engine fuel and keep the electrical components at a stable temperature for longer life. "I happen to believe in this set of weird gears," says George Buhrfeind, the company's president.

Detroit Diesel Corp. has surveyed the continuously variable transmission field for years, found fatal drawbacks to existing designs, and now would like to test an IVT. "We want to be able to get more power, when it's needed, by increasing the speed of our diesel engines used in constant-rpm applications like emergency generator sets for hospitals. A smaller engine can do the job under varying load conditions, if you can somehow keep its output speed constant," says Rob Sisk, vice president of power systems. PS





The IVT takes rotary motion from the input shaft, converts it to oscillating motion, then back to rotary motion at the output shaft. Ratio changes are accomplished by adjusting the position of the index assembly, which varies the magnitude of oscillations in the planetary assembly's four gears and shafts through links and offset crank arms. One-way ratchets in the overrunning gears "rectify" the oscillations back into rotary motion. Two planetary differentials recombine output speed by summing the rectified arm speeds and subtracting input speed. Geared neutral results when the index assembly is adjusted so that oscillations are zero.

ish). Another variation is the front vent sunroof. The front edge is lowered for ventilation, reducing wind noise compared with the conventional rear-lift sunroof. Buick also claims that a better seal is possible with the revised opening.

Buick's Customer's Choice is a system that adjusts the car when one of two remote keyless entry fobs unlocks the door. With a unique signal, each fob instructs the car to adjust seat positions, radio and climate control, and outside mirror positions, as well as the chassis/suspension, power steering and throttle response, and automatic transmission "mode" to the last setting each driver made before leaving the car. Transmission settings include economy or performance, and power assist can be varied for the power steering. Buick engineers note that other features, such as the power tilt wheel, could be added to Customer's Choice, a concept likely to see production.

Yet another concept that Buick would like to see on production vehicles is four-way emergency flashers with strobe lights, which are easier to see than conventional lamps and use little power (no more choosing between no flashers or a dead battery). Some state laws, however, prohibit such applications.

Buick's prototype sunroof changes color electronically to match the car's exterior. A switch makes it clear on command, or it can slide back to admit fresh air.

Buick has also been toying with increased power output from its engines, using superchargers or optimizing naturally aspirated engines—or both. An example of the former is a concept Skylark Supercharged 3100. The standard 3.1-liter V6 has been modified with an Eaton M60 supercharger, a high-flow intake manifold, and larger sequential fuel injectors. With an eight-pounds-per-square-inch boost from the Roots-type supercharger, the V6 produces 183 horsepower and 215 pound-feet of torque that lets the Skylark fly more like a bird of prey and with none of the lag of a turbocharged engine.

A standard supercharged 3800 V6 from the Park Avenue Ultra was installed in a Buick Regal Gran Sport sedan, normally available with a 140-hp non-supercharged 3800. With an additional supercharged 65 hp, this midsize Buick can go head to head with the muscular Taurus SHO. And if that's not enough, Buick engineers massaged 240 hp (and 270 lb.-ft. of torque) out of the 3800 V6 by sand-

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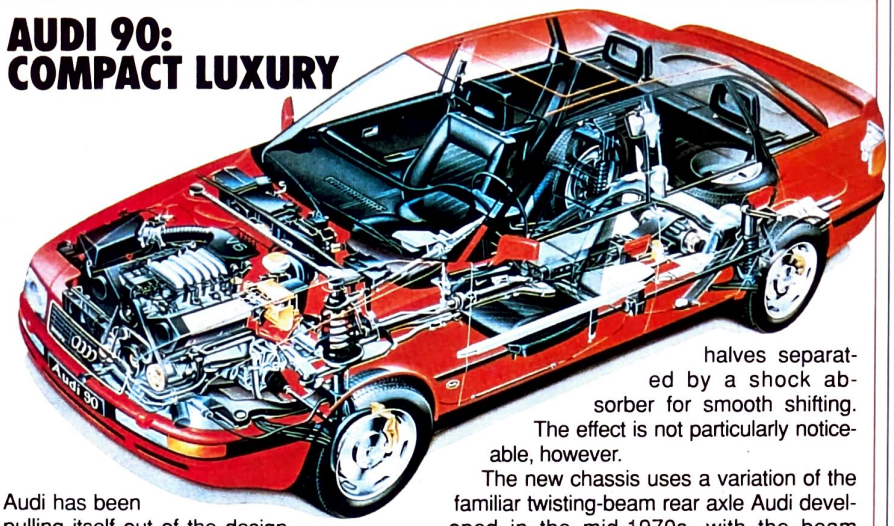
PREVIEW DRIVE

AUDI 90: COMPACT LUXURY



Audi has been pulling itself out of the design doldrums with a revised product line that started last year with a new 100 sedan and now continues with a revamped series of 90 models. Built on a 102.2-inch-wheelbase chassis that Audi engineers claim is the stiffest in production today, the new 90-series cars use the same 172-horsepower, 2.8-liter V6 engines found in the larger 100 series.

The manual transmission version features an unusual two-piece flywheel, the two halves separated by a shock absorber for smooth shifting. The effect is not particularly noticeable, however.

The new chassis uses a variation of the familiar twisting-beam rear axle Audi developed in the mid-1970s, with the beam moved forward to act more like a torsion bar. The result is a softer ride, with less harshness on minor road dents, but firm control in the corners.

Accelerating to 60 mph takes less than nine seconds, and the new Audi 90 thus runs comfortably with the top-handling compact sport sedans. With a starting price in the mid-$20,000 range, the new 90 tops out close to $30,000 with the full four-wheel drive and sport options included.

wiching an inch-thick air-to-water intercooler between a larger Eaton M90 supercharger and the intake manifold—not bad for an engine that in 1985 produced a mere 110 hp in carbureted form.

A "no cost" alternative is Buick's extended range 3800. By using a 9.5:1 compression ratio, tuned intake manifold with 13-inch runners, low-restriction air cleaner assembly, high-flow lightweight cylinder heads, lightweight valve train with roller rockers, and a three-inch downpipe, Buick engineers extended the power curve to a higher rpm range without decreasing the torquey bottom end or lowering its fuel economy. The 3800 is rated at 170 hp for 1992; the extended range pumps out 195 hp. Add a supercharger and output jumps to 243 hp, with 295 lb.-ft. of torque. For traditionalists, a Roadmaster Limited "Special" produces 292 hp and 384 lb.-ft. of torque from an engine that is essentially a Corvette 5.7-liter V8. It's what the Roadmaster should have had in the first place. The big rear-drive sedan rumbles from 0 to 60 mph in 7.9 seconds.

Whether any of these concepts sees production depends on perceived demand.—*John Matras*

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New GT Tire

Designing tires requires a lot of compromise. If you make a tire stiff for performance, it gives a harsh, noisy ride; conversely, if you make a tire flexible for a smooth feel, you lose handling.

Michelin says that its new all-weather MXV4 tire provides the best of both worlds. This H- or V-speed-rated tire is built for owners of sporty luxury cars such as the BMW 525i or Acura Legend, who want as soft a ride as possible while retaining sporty handling characteristics.

Most tire casings are reinforced by a layer of wires that wrap around a cross section of the tire and connect to steel "beads" that circle the inner rim on both sidewalls. This construction is fairly flexible and comfortable. In performance tires, manufacturers add a hard rubber filler to the sidewall to make it more rigid.

The MXV4 is different. It has no rubber filler, but two casing wires: one which wraps around the bead clockwise, and the other counterclockwise. The result, Michelin claims, is a tire that remains stiff both in the direction of travel (for acceleration) and on the sidewalls (for sharp cornering), but still flexible in the vertical direction, producing a smooth ride.

The Michelin MXV4 is guaranteed for 55,000 miles and should retail for between $60 and $120, depending on size.—*Robert Langreth*

Battery progress

The race to develop a mass-produced electric car got into high gear with the selection of the nickel-metal hydride battery developed by Ovonic Battery Co. It's the first technology to receive development support from the Advanced Battery Consortium (ABC), a research group co-sponsored by the U.S. government, General Motors, Ford, and Chrysler.

The consortium was formed to share advanced battery technology among U.S. auto makers and fund the most promising technology. The $18.5 million grant awarded to Ovonic, a subsidiary of Energy Conversion Devices in Troy, Mich., is the first of several grants that will fund work on batteries suitable for electric cars.

The Ovonic battery stores electricity by splitting water in the electrolyte into hydrogen and oxygen [ANF, Apr. '92]; the oxygen attaches itself to a nickel electrode and the hydrogen is stored in an alloy hydride. Discharging the battery recombines the hydrogen and oxygen to form water—the same process used in hydrogen fuel cells.

Ovonic is already licensing several makers to produce the battery, mainly in applications such as laptop computers, where it promises to soon replace nickel-cadmium batteries. Early tests demonstrate the nickel-metal hydride battery has about twice the energy capacity of a lead-acid battery, which could mean about twice its range. The nickel-metal hydride also has a long life and isn't hurt by deep discharges—important characteristics for a battery destined for an electric car.

The principal drawback is cost—about twice that of lead-acid per kilowatt-hour. The Ovonic battery, however, is expected to last the life of the car, rather than needing replacement every 20,000 miles.

Selection of the Ovonic metal hydride battery by the ABC is expected to be followed by similar development grants for other promising new batteries, including the sodium-sulfur battery favored by Ford, BMW, and Mercedes-Benz. A spokesman for GM, which reportedly still is aiming at a 1994 introduction of its Impact electric car, says that lead-acid currently is the only mass-produced battery available at a reasonable cost, but sees considerable promise in advanced technologies for the future. PS

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	'92 Buick LeSabre Limited	'92 Toyota Cressida Sedan
Engine	3.8-litre V6	3.0-litre Inline 6
Drivetrain	Front Drive	Rear Drive
Passenger Room	109.2 cu ft	89.0 cu ft
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Driver Air Bag	Standard	Not Available
Anti-Lock Brakes	Standard	Optional
M.S.R.P.*	**$21,100**	**$25,558**

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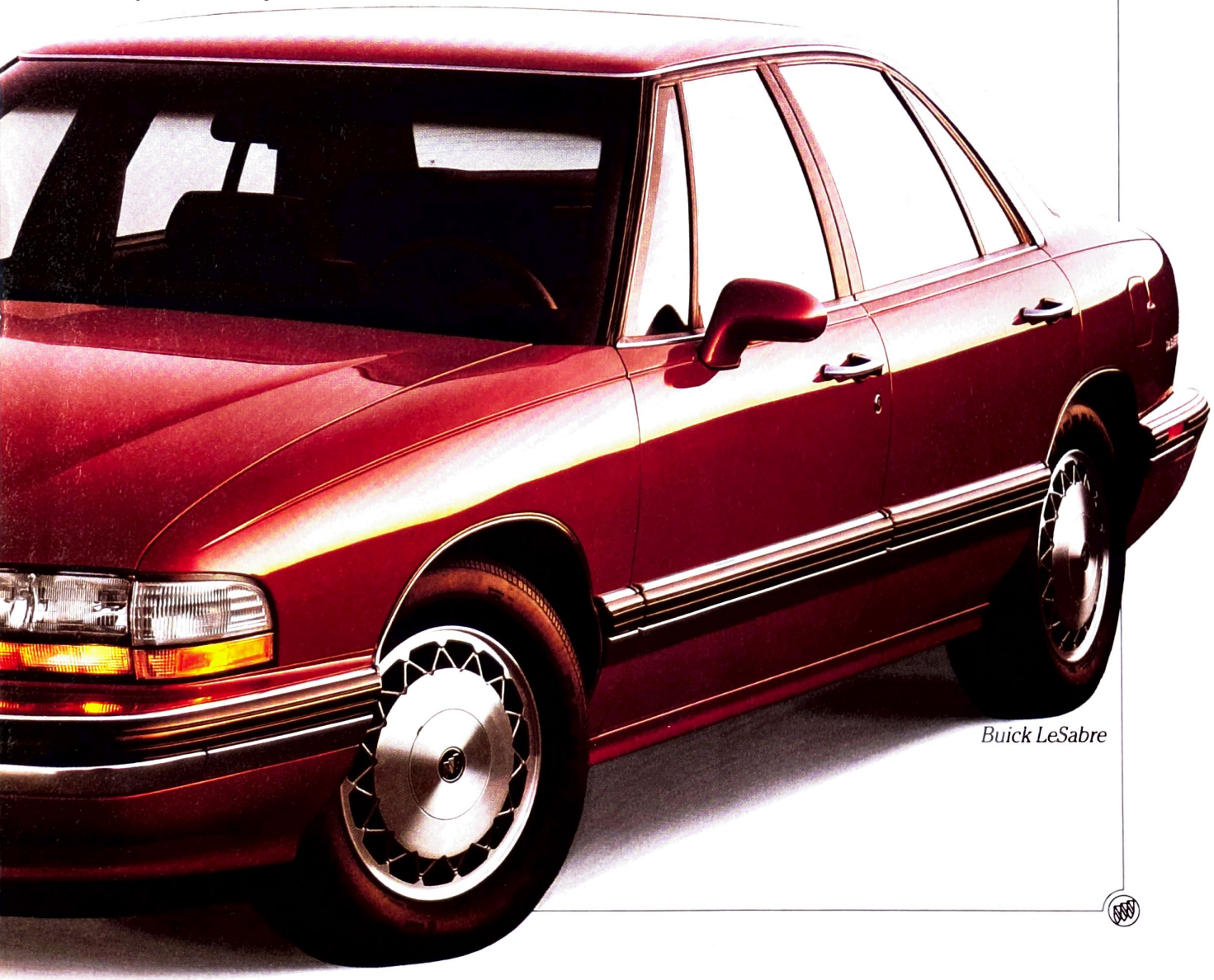
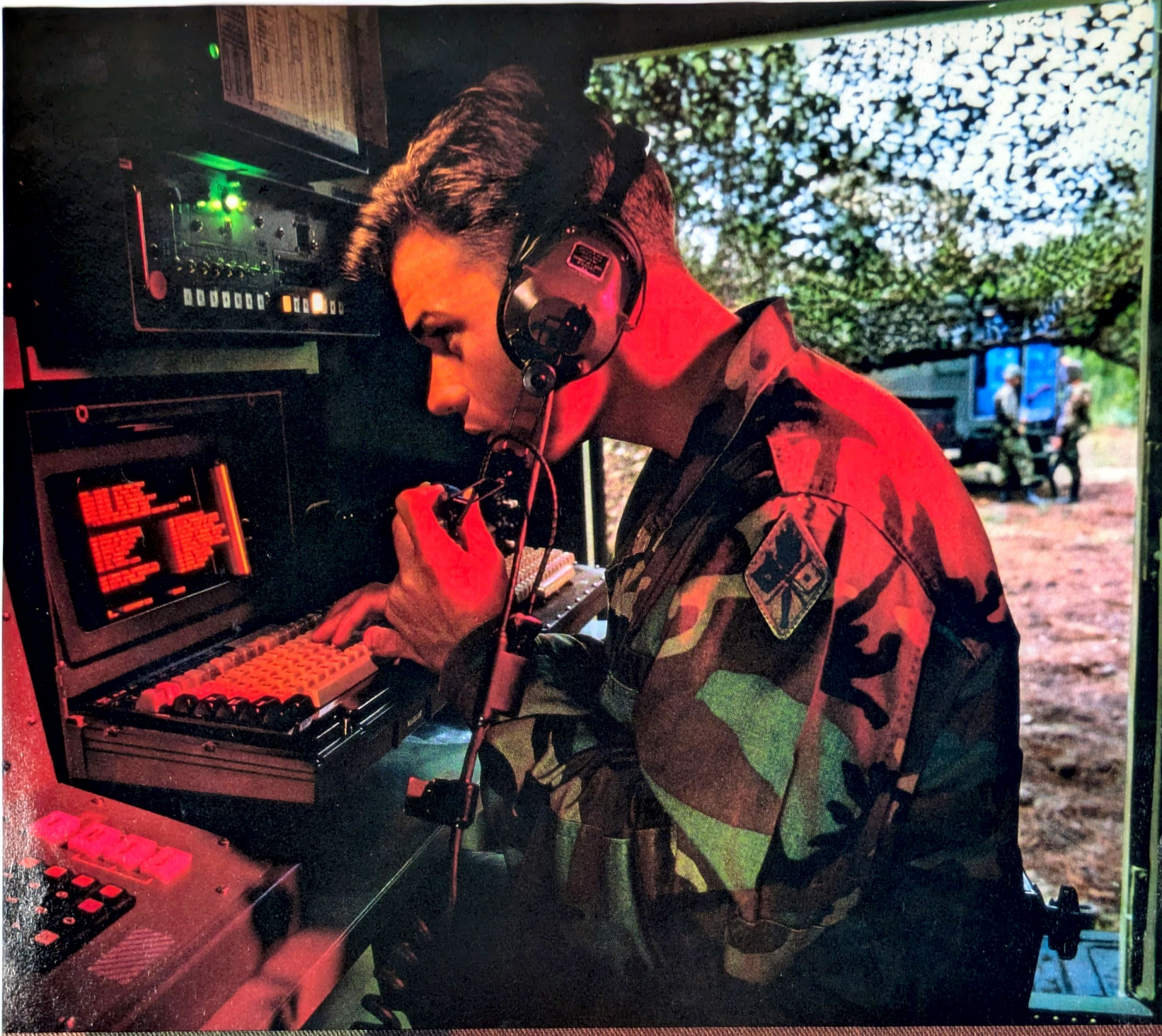


Buick LeSabre



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Electronics Newsfront

Edited by JOHN FREE

Virtual acoustics

Imagine listening to a symphony recording and being able to "walk" through the instrument section of the orchestra, hearing how the sound changes. Or imagine slipping on a pair of headphones at a giant-screen IMAX theater, discovering that the sound track from the movie immerses you in 3-D audio that dramatically enhances the visual realism.

Those are a few uses for a new method of manipulating a listener's spatial perception of sound, says Elizabeth Wenzel, a psychologist at the NASA Ames Research Center in Mountain View, Calif. NASA's research into "virtual acoustics," not surprisingly, may also lead to serious applications: helping air-traffic controllers monitor aircraft in crowded skies and at airports, for example.

An audio demonstration with stereo headphones produces remarkable effects. Narration from the movie *Apocalypse Now* and music by the rock group Talking Heads seem to be coming from opposite corners of a room. Pivot your body 180 degrees and the sound sources reverse positions smoothly. Walk toward the apparent location of the movie sound track and its volume increases while the rock music fades. Further exploration of this virtual space makes the movie sound track appear at a different elevation than the rock band.

The headphones were attached to a Polhemus Navigational System, a magnetic tracking device that tells a computer the position of your head as you move about. This information is fed into a Convolvotron, a specially designed pair of digital-signal-processing boards in a standard desktop computer. These boards, made by Crystal River Engineering of Groveland, Calif., receive audio inputs from a bank of CD players, processing the sound before it's sent to the headphones. Listeners discover that being "inside" this acoustical landscape creates a lavish virtual reality without expensive visual graphics.

Wenzel cites two recent air disasters that might have been averted with spatial audio cues. In one, a pilot shut off the wrong engine when he learned a fire was in progress. In another, an air traffic controller directed two planes onto the same runway.

The Federal Aviation Administration plans to install a Convolvotron at its Atlantic City, N.J., airport research center. According to Lloyd Hitchcock, technical program manager for the center's Air Traffic Control Technology Branch, test results could be reported later this year.

At least two experiments are planned. In the first test, says Hitchcock, "if American Airlines 126 is coming in south by southwest, that's where the simulated sound will appear to be coming from to those in the tower." Closer planes will seem to be louder. Researchers want to see whether these directional cues will enhance controller awareness.

The second test involves the so-called cocktail party effect, which enables you to discern a specific conversation while several persons are talking nearby. In a noisy helicopter, for example, the pilot might hear several messages from different sources simultaneously. The test would set up an artificial directionality that puts each conversation in its own space. Cockpit alarms, such as those from each engine, might also be spatialized.

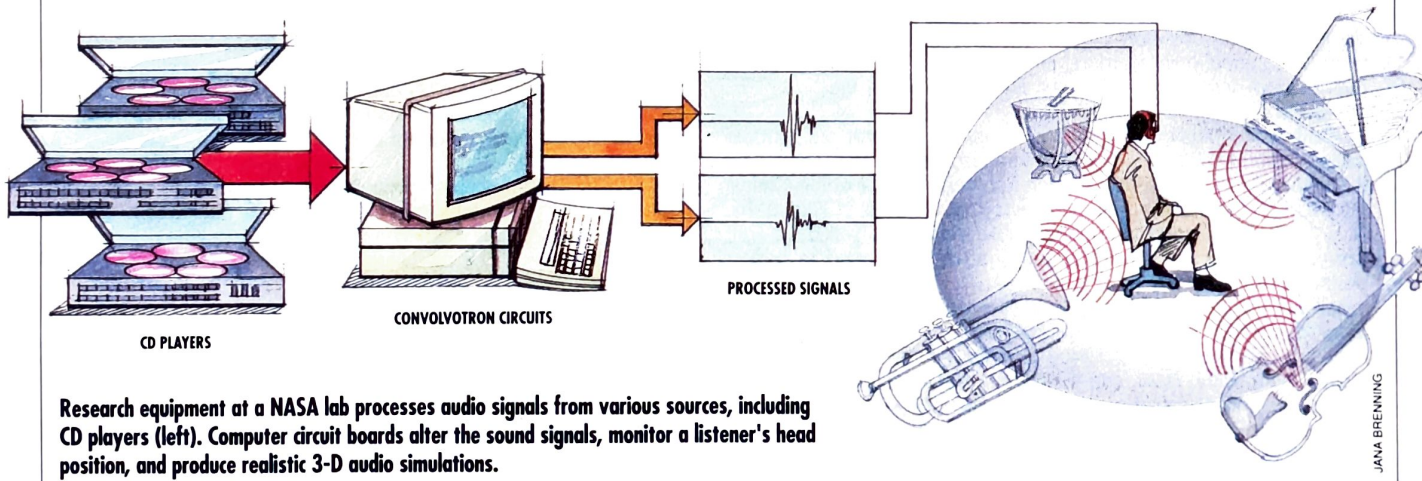
In an on-board collision-avoidance system, designed to detect aircraft on a collision course, the audible word "traffic" could be spatialized so pilots might spot an oncoming aircraft sooner. Wenzel says NASA might also employ the system to help astronauts control robots near space stations. Audio cues would help them judge distances as mechanical arms are swung toward objects.—*Michael Antonoff*

Modems max out

An international telephone-communications committee is readying a new standard for computer modems, which transmit data encoded as analog audio signals over telephone lines. Data could be transferred up to three times faster than today's fastest modems.

The unnamed standard, dubbed V.fast, is expected to hike the top speed of new modems to 28,800 bits per second (bps), up from the current maximum of 9,600 bps (the so-called V.32 standard). These V.fast modems achieve such speeds thanks in part to new sampling or "probing" techniques that enable them to sense and adjust to varying line conditions. As with previous modem standards, data-compres-

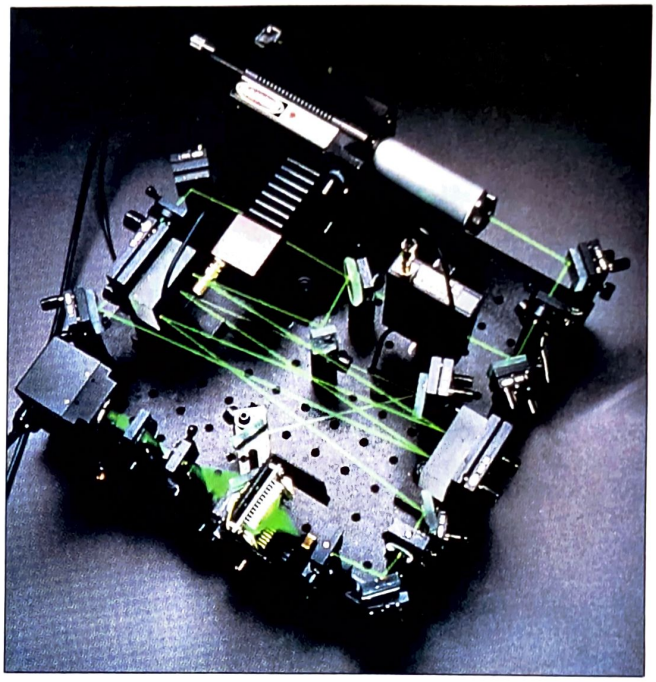
CREATING NEW ACOUSTIC LANDSCAPES



Research equipment at a NASA lab processes audio signals from various sources, including CD players (left). Computer circuit boards alter the sound signals, monitor a listener's head position, and produce realistic 3-D audio simulations.

MEMORY CRYSTAL

BY ELLEN MURASKIN



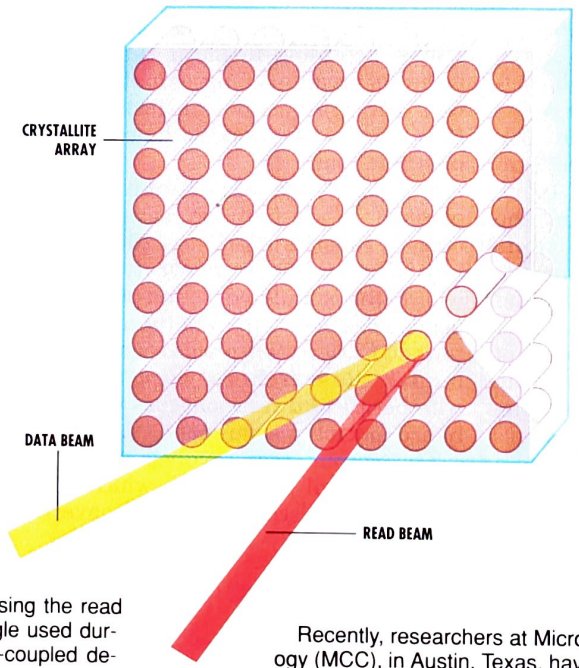
A typewriter-size holographic memory device being refined at MCC uses an array of narrow crystals. Each captures data along its length as stacked "pages" of tiny holograms.

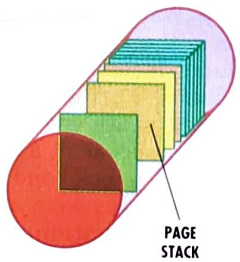
Researchers are refining hardware that will enable you to order movies in your living room from automated film libraries. A 90-minute feature, transmitted in digitally compressed form over optical fibers, would be downloaded within minutes into a home storage device, then played back at your convenience.

Such storage demands huge memory capacity and tremendous speed. Traditional optical or magnetic disc recorders with write/read heads mounted on electromechanical moving arms are too sluggish. Now, after decades of study in labs around the world, holographic recording techniques capable of capturing data within crystals are finally becoming practical. No moving parts are involved. Advanced versions of these "crystal jukeboxes" will be able to store more than ten gigabytes (billion bytes) of data—1,000 times faster than disc recorders—in a volume smaller than a sugar cube.

Holographic memories achieve incredibly dense storage capacities in part because they organize data in 3-D layers throughout a crystal. Such data can be accessed much faster than with conventional memory technologies, which organize data in time-consuming serial fashion, one bit following another. By contrast, all one million bits of data stored in a layered "page" within a holographic memory crystal could be retrieved or written at the same instant.

Here is how these holographic memory devices work. Two laser beams—a data beam and a read or reference beam—intersect within a storage crystal to store information. The data beam picks up digital information as a pattern of light and dark spots when it passes though a spatial light modulator. At the intersection point of the beams, the crystal's optical properties change. Information stored in the resulting optical pattern is recreated by passing the read beam through the crystal at the same angle used during recording. A detector, like the charge-coupled device (CCD) used in camcorders, then converts the light pattern back into digital electronic signals useful to the computer.





STEVE STANKIEWICZ

Different techniques are used to capture and read out multiple pages. "One way of storing multiple images is to change the angle of this reference beam," says Ann Von Lehmen, director of the Optical Information Technology Research group at Bellcore in Red Bank, N.J. Traditionally, so-called acousto-optic crystals, which bend light according to signals applied to them, have been used to deflect beams a fraction of a degree.

Bellcore's approach, so far limited to image retrieval, employs an array of microscopic lasers. At the Red Bank lab, Von Lehman shows me a tiny chip under a microscope covered with rows and columns of these lasers. Each laser, she explains, is assigned its own page; a lens deflects its beam at a unique angle into the crystal. Bellcore is working to boost the number of lasers on a chip beyond the 1,024 available early this year.

Recently, researchers at Microelectronics and Computer Technology (MCC), in Austin, Texas, have sidestepped the problem of beam deflection in another way. We achieved "a tremendous simplification in the design," according to Stephen Redfield, director of MCC's Optics in Computing program. MCC uses "phase encoding" that electronically makes the laser beam appear to be coming in at different angles.

"With a traditional acousto-optic deflector, the deflection angle is pretty small, so you need a long travel space for the beam and a lot of mirrors," says Redfield. Eliminating these optics allows designers to shrink the size of the hardware as well as write more pages of data.

MCC's prototype holographic memory device is planned as a replacement for hard-disk drives in personal computers, although military or supercomputer applications may come first. Among the remaining challenges: speeding up spatial-light modulators and CCD detectors. With these optimized, and with page sizes of one million bits and a parallel readout 32 bits wide, the theoretical rate of data transfer would be nearly one billion bytes per second. PS

sion schemes could raise the effective data transfer rate of a V.fast modem by a factor of two, three, or even four. To computer users, that means much faster transmission of digital files, which have grown increasingly large as graphics-based software replaces text-based programs.

The Consultative Committee for International Telephony and Telegraphy, the arbiter of modem standards, is expected to complete its work on V.fast by mid-1993 and make the standard official by late 1993 or early 1994. Modems using the new standard may begin appearing before its formal debut.

But with analog phone lines being pressed to their outer limits and with all-digital lines on the horizon, V.fast could spell the beginning of the end for computer modems. "I don't foresee any new standard beyond V.fast," says Dale Walsh, vice president of advanced development at U.S. Robotics Inc., a modem maker in Skokie, Ill.

Although analog lines have improved substantially in the past two decades, Walsh and others say major new advances in the quality or capacity of analog lines are unlikely. In addition, a fully digital phone network—often referred to as Integrated Service Digital Network, or ISDN—would eliminate the need for conventional modems. Instead, computers and facsimile machines could send and receive digitally coded information without the need for analog conversions. But wiring every home and office for digital service will take years, possibly a decade or more. Modems won't be obsolete anytime soon.—*Christopher O'Malley*

Global shipping monitor

The United States Coast Guard recently completed a major redesign of its Automated Mutual-Assistance Vessel Rescue System, or AMVER. This computerized database, called AMVER II, enables the Coast Guard to keep track of the thousands of merchant ships that have agreed to assist endangered vessels.

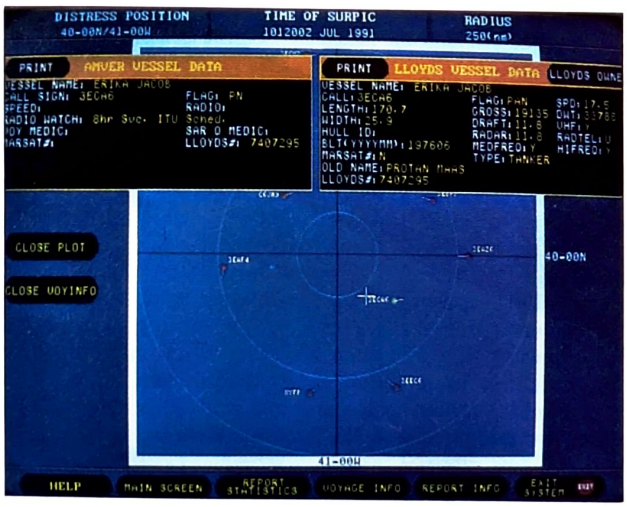
At the heart of AMVER II is a large database of information that includes the size, ownership, speed, and travel plans for ships from 124 countries. Participating craft radio their positions every 48 hours. This provides the Coast Guard with a worldwide fleet of rescue ships able to reach foundering vessels rapidly. The monitoring system also means that only necessary rescue resources are diverted to emergency sites.

Previous versions of the system simply displayed columns of numbers on a screen. The new design features computer graphics. "We now have the tools to make intelligent decisions very quickly," says Brice Kenny, chief of marketing and communications at AMVER Maritime Relations on Governors Island in New York Harbor.

AMVER II's increased efficiency is welcomed at the Coast Guard Atlantic Search and Rescue Center also on the island. Lt. Jeff Hughes, a controller at the center, recently demonstrated the updated system. According to Hughes, when a distress call comes in, he or any operator in 1 of 12 rescue centers around the world can connect to the Coast Guard's main computer center, located in Martinsburg, W.Va.

Hughes called up an AMVER II graphics screen that showed a particular latitude and longitude and all of the ships nearby. Clicking on any vessel brought up a list of information, including maximum speed and available medical personnel. In an emergency, Hughes would contact the ship that is best able to help. Though captains are not required to respond, most do—because one day it may be one of their ships that's in need of assistance.

With the new software in place, the next step is enrolling as many ships they possibly can. "The bigger the system," says Kenny, "the better it works." He hopes to begin logging in cruise ships sailing from U.S. ports. —*Vernon Church*



A computer graphics update for the Coast Guard's vessel database enables controllers to quickly pinpoint other ships in the vicinity for emergency rescues.

Moby Brick take-along computers are designed for use at different sites that have a keyboard and video monitor.

A take-along desktop

Moby Brick is one-fifth the size of a standard desktop computer, yet more powerful than most models. Inside the encyclopedia-size charcoal-gray case is a liquid heat sink to help cool its microchips.

Based on an Intel 33 megahertz 486DX processor, Moby Brick is able to redraw color screens in lickety-split

Pursue The Heartbeat Sweepstakes

Just answer question 3 correctly, and you could win a free trip for a parent and child to U.S. Space Camp and a new Pentax PZ-10 35mm Autofocus camera. The answer to question 3 can be found in this issue (hint: look for the Chevrolet ad.)

1. What year was the Chevrolet Corvette introduced?
2. What year was the Camaro introduced?
3. What type of brakes are standard equipment on the Chevrolet Lumina Euro Sedan?
   Hint: Find Lumina ad inside this issue.

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Answers

1. 1953
2. 1966
3. _____

Name _____

Address _____

City _____ State _____ Zip _____

SUPER-DENSITY FLOPPIES

Floppy disks and drives are going perpendicular—but this has nothing to do with their physical orientation in personal computers. A different approach to storing data magnetically on floppy disks, called perpendicular recording, is taking hold in the computer industry, boosting the storage capacity of floppies.

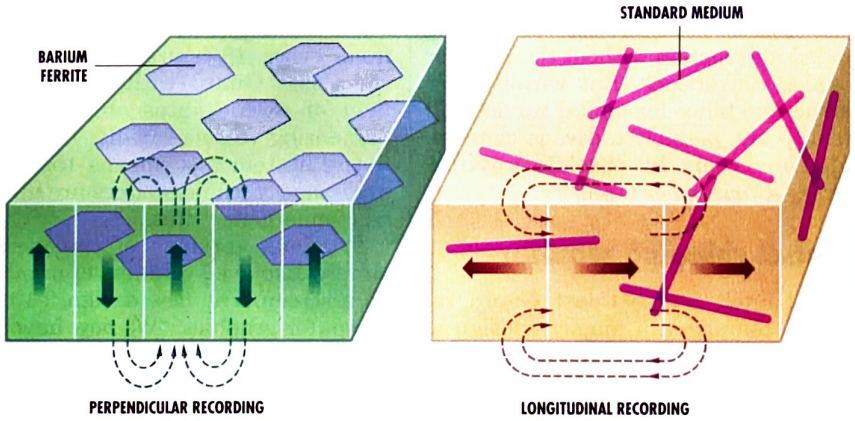
First proposed by a Japanese professor in 1977 and perfected by Toshiba Corp., perpendicular recording crams more data "cells" (the magnetized particles that store electronic pulses representing digital code) onto a disk's surface than conventional floppies. Unlike standard floppies, strewn with needlelike particles that are magnetized horizontally, floppies using the perpendicular recording technique are tightly packed with hexagonal platelets made of barium ferrite.

The platelets are magnetized vertically (or perpendicular to the recording surface). Barium-ferrite particles and the vertical recording procedure not only allow for a closer arrangement of data cells, but the very sharp magnetic transition between adjoining particles within cells also improves data reliability.

The first mainstream application for this technology is a new generation of 3.5-inch floppy drives that handles twice as much data as 1.44-megabyte drives used in IBM-type computers. Toshiba is actively promoting its 2.88-megabyte technology as the next standard. The company has licensed the technology to all major drive and disk makers. The 2.88-megabyte drives can read from and write to older lower-density formats.

Although Next Inc. used these drives for its new computer two years ago and a few others have followed, the new format has been slow to catch on. Part of the reason is that the 2.88-megabyte drives cost computer makers about $20 more apiece than standard drives. But IBM has begun using the drive in its PS/2 models, and Apple is expected to include it in a new system later this year. "IBM was really the big breakthrough," says James Porter, president of market researcher Disk/Trend Inc. in Mountain View, Calif. "A year from now, we'll see the [2.88-megabyte] floppies on all high-end PCs."

Several drive makers are already looking well beyond the 2.88-megabyte mark for 3.5-inch floppies. Insite Peripherals of Santa Clara, Calif., and Brier Technology of Norcross, Ga., have each developed drives that store more than 20 megabytes on 3.5-inch floppy disks coated with barium ferrite. New 50-megabyte floppies are in the works as well. But such hardware is still very expensive, adding hundreds of dollars to the cost of a computer system, compared with $70 or less for 2.88-megabyte drives. And there is no standard format as yet for these super-high-density floppies.—*C. O.*



Higher-density disks record data in a perpendicular format (left) within a barium-ferrite medium. Standard-density disks are magnetized horizontally, requiring more space.

time. Text lines from a disk-operating-system directory command scroll by too quickly to read. Because almost every cubic inch of the computer is packed with circuitry, there's only room for a half-size add-in card. Eliminating all of the empty space that other computer makers reserve for expansion options enables Brick owners to stash the machine in a shoulder bag. At 8.6 pounds, Moby Brick is a heavyweight by notebook computer standards, yet few notebooks can claim its speed, 3.5-inch floppy and massive hard disk (80 to 510 megabytes), memory (4 to 32 megabytes), internal 2,400 bits-per-second modem, and high-resolution display adapters.

Ergo Computing, the Peabody, Mass., company that manufactures Moby Brick, is aiming at users who need to move their computer and files between different offices or between home and office. Even if they don't boot up at home, they at least know where their valuable data is stored. There's a premium charge for

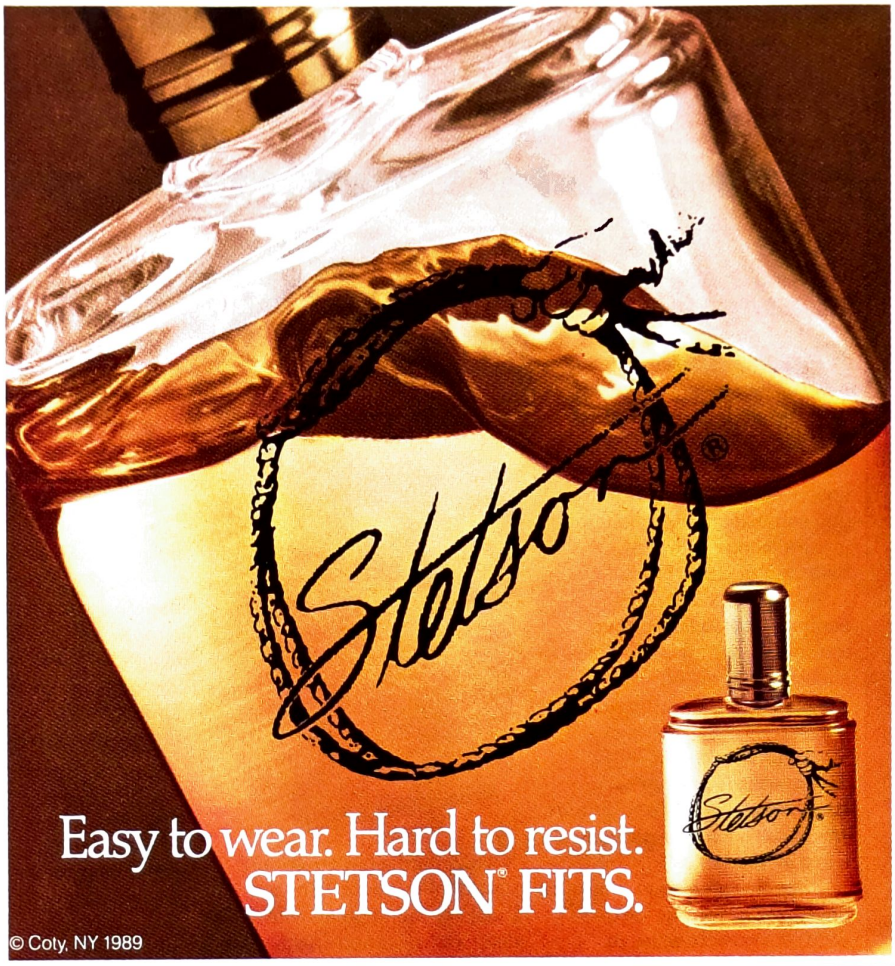
this portability: $3,995 to $7,795, depending on the configuration. There is no battery option. Ergo assumes that monitors and keyboards have become so prevalent that you're likely to find them in just about any workplace, though extras include a keyboard ($109); VGA-compatible (video-graphics-array) monochrome backlit liquid-crystal-display panel ($995); docking station ($395); and carrying case ($99).

A Moby Brick that was shipped for evaluation arrived loaded with DOS 5.0 and Windows 3.0. With a keyboard and VGA monitor from another desktop plugged in, Ergo's tiny computer was soon off and running quite successfully. But a problem arose at another site when the Moby Brick was plugged into a lower-resolution EGA (enhanced-graphic adapter) display. The screen remained dark until someone figured out that tiny recessed microswitches should be reset. As the memory test ran, the display remained lit for only a brief time. And when an auto-batch file tried to load Windows, the screen went dead once again. The software was defaulting to VGA; it wasn't compatible with an EGA monitor.

Ergo recently introduced its Ultra Moby Brick, based on the 50-megahertz 486DX2. Equipped with a graphics coprocessor for 1,280-by-1,024-pixel super VGA, the company claims it's ten times faster than standard VGA. Also, special circuits for text fonts make the characters look much sharper on the screen—nearly 300 dots per inch, according to Ergo.—*M. A.*

Electronics notes

- A new breed of coat-pocket-size computers will be introduced early next year by Apple Computer. Graphics or printed notes are stored by writing electronically with a pen on a notepad-size LCD screen. Plug-in cards can expand its built-in electronic organizer functions, and special software "learns" routine operations. Details next month.
- As for the latest developments in high-definition television (HDTV), Zenith and AT&T tested their digital-HDTV system by broadcasting noise-free pictures 75 miles over channel 36 from Milwaukee to Glenview, Ill. The system is one of several in competition to become the U.S. standard. Meanwhile, Sony Corp. has slashed the price of its HDTV sets 70 percent, to about $9,600 in Japan. Videodisc movies will augment satellite HDTV broadcasts there. PS



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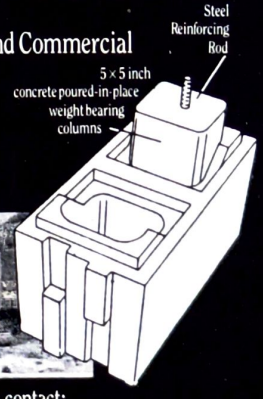

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In 1991, an electronics company called **Datawave** introduced their line of wireless speakers at the ***Consumer Electronics Show***, turning the heads of some of the largest manufacturers in the world. ***These wireless speakers have been touted as "one of the most exciting new products of the 90's."***

Imagine listening to music anywhere in your home or outdoors without miles of speaker wire. You could listen to any component of your stereo system (CDs, records, tapes, AM/FM stereo,... etc.) throughout your home. Like the speakers of your dreams, they have their own built-in amplifier, so you can switch them on and off and control the volume independently at each speaker. These self-amplified speakers cannot be blown out, regardless of your stereo's wattage.

"Our TV and stereo are in the same room and my husband and kids were always fighting before we got the Datawave speakers. Thanks for bringing peace to our family!"
D. Lance, Madison, WI

PATENTED DESIGN

The heart of Datawave's breakthrough design is a patented FM technology which broadcasts music wirelessly from a small transmitter to satellite speakers. ***The transmitter, about the size of a paperback book, sends the music through walls, floors, and ceilings to the speakers*** and simply plugs into a headphone, audio-out or tape-out jack on your stereo, VCR or TV.

WS7 SPEAKER

Now for the big question– How do they sound? These speakers sound great, with deep, rich bass and crystal clear highs. You see, these speakers operate on two selectable frequencies, insuring static-free transmission throughout your home. The speakers are self-powered, with a 150 ft. range through walls, providing total coverage in even the largest homes. These wireless speakers will belt out as much volume as you'll ever need to fill your rooms with music. They even have an amazing built-in detection circuit which automatically cuts them off when you turn off your stereo.

MUSIC ANYWHERE

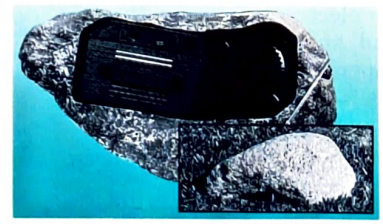
You can operate as many speakers as you like on one transmitter. In addition, you can utilize one transmitter to mix both left and right channels on each speaker or use two transmitters with as many pairs of speakers as you want to get full stereo separation. So place one speaker or more in a room or one speaker in every room of the house–the possibilities are limitless!

All of these wireless speakers are compatible, using the same transmitter, so you can mix and match them to fill your home with music. So listen to your stereo where you want, and take advantage of the following assortment of innovative wireless speakers.

• **WS7**, our **classic wireless speaker**, available in either black or white in an attractive, water-resistant enclosure. Designed with a 360 degree sound pattern to blanket a room with clear, crisp music. Operates on 4 C-batteries, which will power the speakers for about three months, or on an optional AC adapter.

• **WSH-7**, our wireless **shower speaker**. Listen to news or sports programs while in the shower or sing along to your favorite music. This speaker is hung directly from the shower head and is fully waterproof.

• **WRS10**, a wireless speaker mounted in a rock-like enclosure. The **rock speaker** is an ultra-realistic reinforced fiberglass boulder that contains a state of the art FM receiver and weatherproof speaker. The downward firing speaker and acoustic enclosure are designed to resonate and enhance the bass. Designed for patio, garden, and pool areas, it blends in completely with your surroundings.



"I'm not a gadget guy, but these speakers amazed me. They're not only wireless, but sound great too!" *M. Thompson, San Diego, CA*

• **WH200**, a **wireless headphone** that allows you to enjoy private TV sound or music anywhere in or around your home.

"I have a great sound system in my family room, but I'm not always in that room. Now I can listen to my favorite CDs anywhere in my home even on the patio." *J. Randal, Reading, PA*

EXCLUSIVE OFFER

For a limited time, we are offering the Datawave line of wireless products directly to consumers ***far below retail price! This offer will not be made available in stores!***

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Call Toll Free 24 Hours a Day.

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Item# Description	Price	S&H
WS7 spkr with transmitter	$99	$6
WS7A extra speaker	69	6
WRS10 rock spkr + trans	159	8
WRS10A extra rock spkr	129	8
WSH-7 shower spkr + trans	129	6
WSH-7A extra shower spkr	99	6
WH200 headphone + trans	69	6
WH200A extra headphone	39	4

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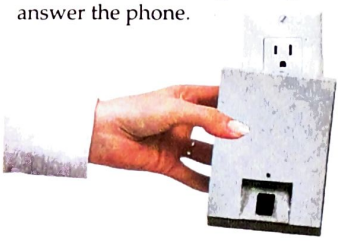
NEW! NEW! NEW!

The Amazing "Wireless" Phonejak

Converts any electrical outlet into a phone jack.

It's amazing but true! This is a telephone breakthrough for the entire family. **Imagine** having a convenient phone extension in your kitchen. Especially when the tea kettle is screaming. The dish water is running. The soup pot is boiling over. The guests are coming in 15 minutes. And the phone starts ringing. **Imagine** the thrill of having a phone in the laundry room, especially when you need to get away from all the busy family noise. **Imagine** having a phone in the bathroom when you step out of the shower dripping wet. No more running through the house naked to answer the phone.



Now you can have all this and more with the new *PHONEJAK*. You can have an instant phone jack in any room of your house.

ITS QUICK AND EASY

No dangerous telephone cords stretched from here to there, no expensive technology and no running up a huge installation bill from the phone company. All you need to do is plug in the fantastic *PHONEJAK* into any regular wall outlet. You'll thrill to be able to move your phone to rooms or areas that have never had jacks before. The *PHONEJAK* gives you all the freedom of having cordless phone technology, without the "cordless" phone. Here's how it works. This fabulous breakthrough uses "cordless" phone technology. The *PHONEJAK* comes complete with two units: 1. The base unit. 2. The extension unit.

The base unit plugs into your regular phone line like an answering machine. The extension unit can be plugged into any 3-pronged electric wall outlet. This extension is your instant phone jack. With this, you'll have the freedom to put your phone anywhere you like. Plus, the base unit can transmit its crystal clear signal to any number of rooms with *PHONEJAK*.

UNLIMITED EXTENSIONS– NO MONTHLY CHARGE.

It's a fact. Most phone lines can only handle up to 5 extensions with regular phone jacks installed from the phone company. Not so with *PHONEJAK*. You can have as many as you want. Six, ten, there's no limit. And with *PHONEJAK* you will never have a monthly charge for your extra extensions.

Plus, this breakthrough technology will work for all of your single line phone needs. It will operate your fax line, your answering machine, *PHONEJAKS* will even handle your computer modem.

WHO SHOULD BUY ONE?

- Anyone who wants more telephone extensions without the hassle and expense of calling the phone company
- Anyone with enough kids to know the problem of "telephone privacy."
- Anyone who wants to put the answering machine or FAX into a more convenient place.
- Anyone who is moving and not sure where to put the phone jacks. *PHONEJAKS* can be moved from room to room.
- *PHONEJAKS* are ideal for renters who don't want to put in permanent phone jacks.
- Anyone who wants the convenience of answering the phone quickly and safely.

THIS OFFER IS NOT AVAILABLE IN STORES.

The *PHONEJAK* is so new and innovative you won't find it in stores. The *PHONEJAK* is being offered to our readers at a special direct-to-you introductory price. This great product will carry a retail price of $140.00. But not for you. You pay only **$99** if you respond now.

We are offering you this revolutionary telephone extension system for 30% off. You pay only **$99**. ($6 shipping and handling.) This price includes the Phonex base unit plus one extension.

Plus, for a limited time you can order extra extensions for just **$69** each. And if you mention the promotional code (found below the toll-free number) you'll get a surprise mystery gift **FREE.** This free gift is yours to keep even if you decide to return the *PHONEJAK*.

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Item #	Description	Price	S&H
PX101	*PHONEJAK* Base Unit + 1 Extension.	$99	$6
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Turn every outlet into a phone jack. Plus, get crystal clear reception anywhere in your home or office with the *PHONEJAK*. Most orders ship within 72 hours. Please mention promotional code **PS1105.**

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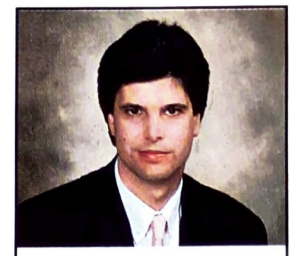

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Home Newsfront

Edited by MARIETTE DiCHRISTINA

Shallow foundations

Long used in Scandinavia, a frost-protected shallow foundation enhances the energy efficiency of slab-on-grade homes while slashing construction costs. In cold climates, most builders protect foundations against frost heaves by placing footings below the frost line, which is about four feet deep in the northeastern United States. But the frost-protected shallow foundation uses insulation and drainage techniques to raise the frost line to just below the surface (see illustrations).

The system consists of a concrete slab and a 12-inch-deep stem wall that is covered with two-pound-density rigid polystyrene insulation. This insulation captures any heat escaping from the house through the slab and directs it to the base of the footing. The footing, in turn, rests on a four-inch-layer of washed gravel or rock, which forms a nonporous barrier against subterranean water. Surface water is directed away from the foundation by sloping the finish grade a minimum of 1/2 inch per foot.

The system's effectiveness was recently confirmed by temperature probes around the new foundations in the Midwest. When the temperatures of the probes that were buried three feet underneath uninsulated ground fell below freezing, those at the base of nearby shallow foundations ranged between 37°F and 40°F.

By using shallow foundations, Bill Eich, a builder from Spirit Lake, Iowa, saves an average of $1,500 in construction costs on each of his typical homes with an attached garage and a walk-out basement. In fact, the National Association of Home Builders (NAHB) of Washington, D.C., estimates that the foundations could save consumers nearly $300 million in annual construction costs.

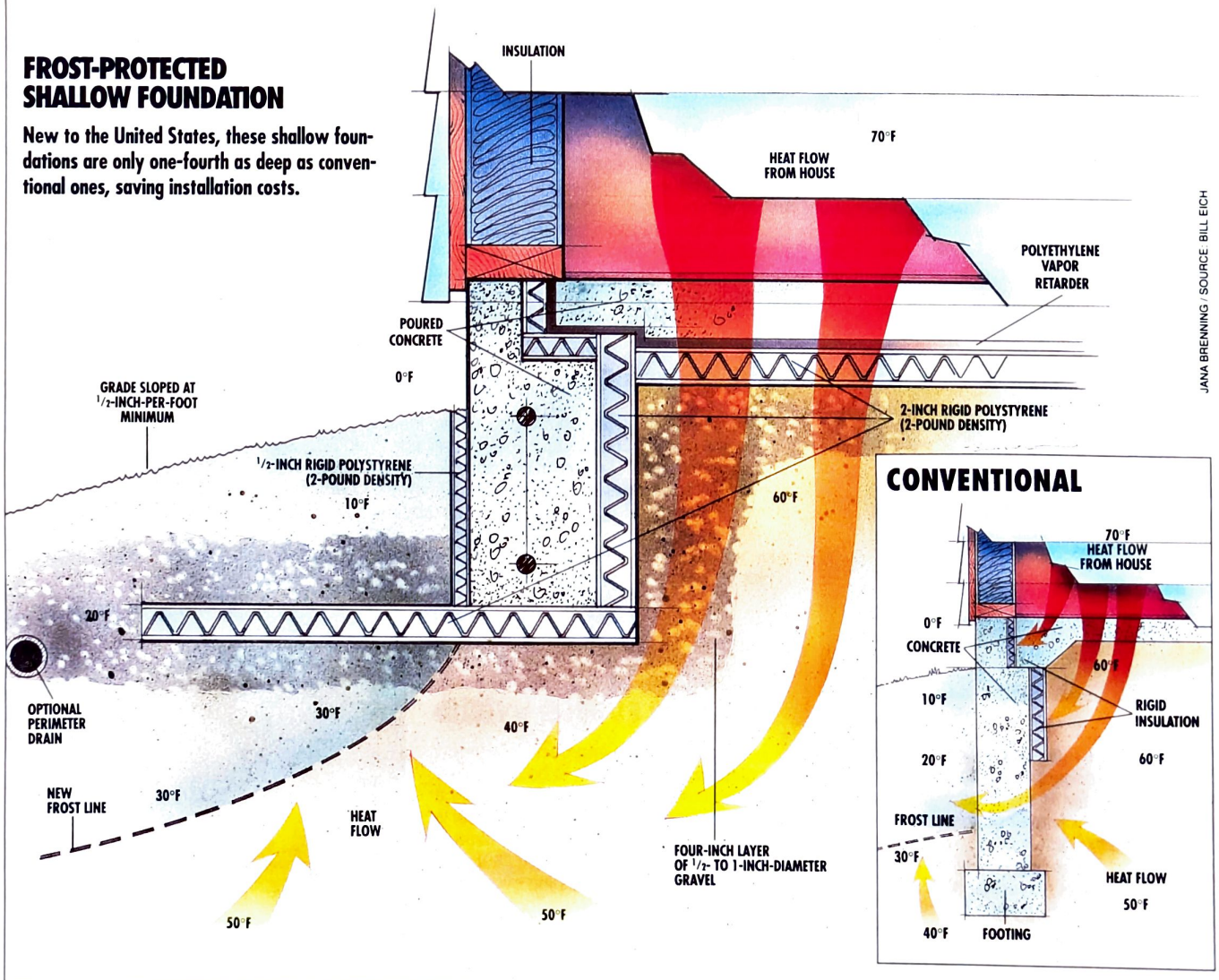
The next step is code acceptance: The NAHB and the Society of the Plastics Industry of Washington, D.C., are working to get the system included in the four U.S. model building codes. They expect to see specifications in at least three of those codes by next year.—*Charles Wardell*

Storing cooling

To achieve greater efficiency, central air-conditioning systems have traditionally relied on improvements in compressors and larger condenser and evaporator coils. But the newer units still inherit their predecessors' faults:

FROST-PROTECTED SHALLOW FOUNDATION

New to the United States, these shallow foundations are only one-fourth as deep as conventional ones, saving installation costs.

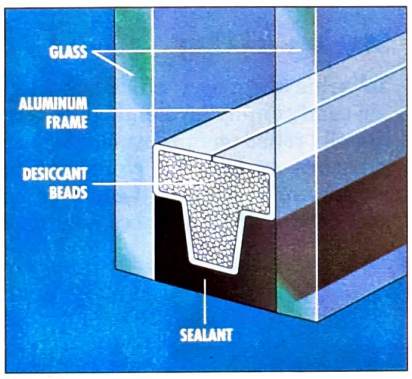


JANA BRENNING / SOURCE BILL EICH

CLOSING THE GAPS IN WINDOW EFFICIENCY

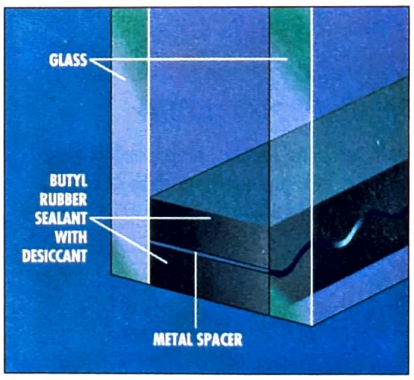
BY ALEX WILSON

As window glazings have dramatically improved thermal performance, manufacturers have turned their attention to the edges, where today proportionately more heat can be lost than through the glass. New approaches to edge design include using spacers made with material that is less heat conductive than conventional metal. One problem with this is that these so-called organic spacers may outgas, coating the inside of the glass with a polymer film that impedes performance. The incentive to retain metal spacers is also strong because manufacturers have so much money invested in equipment to bend the metal. To save energy and still retain metal, manufacturers substitute lower-conductivity metals such as steel, reduce metal thickness, and use different shapes—such as a "C" cross-section instead of a "D." PPG, Cardinal Glass, and Allmetal are among the manufacturers employing this approach. Here is how window-spacer designs have evolved:



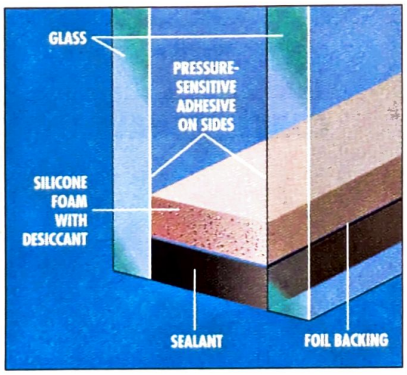
CONVENTIONAL SPACER: ALUMINUM

In conventional edge designs for insulated glass windows, tubular metal spacers are filled with desiccant, a water-absorbing material. Aluminum has been the preferred spacer material because it is easily bent during window fabrication, but it's also an excellent heat conductor, which reduces overall energy efficiency. The heat loss through this type of aluminum window-edge spacer can offset a lot of the efficiency gains that are provided by high-performance glazings and insulative gas fill.



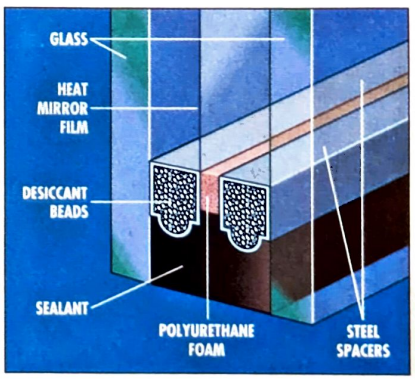
SWIGGLE: LESS METAL

Tremco Corp. of Beachwood, Ohio, was one of the first manufacturers to address concerns about heat loss through window edges when it introduced the Swiggle Strip spacer in 1979. Composed of low-conductivity butyl rubber with built-in desiccant and just a strip of corrugated metal for structural rigidity, Swiggle Strip has gradually gained acceptance among manufacturers, says Tremco's Jim Plavecsky. Swiggle Strip's conductivity is one-quarter to one-half that of a standard aluminum spacer, which improves overall window energy performance by several percentage points.



SUPER SPACER: FOAM WITHOUT METAL

In 1989, Edgetech of Ottawa, Ontario, upped the energy-savings ante with a spacer that uses no support metal. Super Spacer employs silicone foam rubber with a built-in desiccant and a foil backing to prevent diffusion of insulative gas. The silicone foam rubber is one-quarter to one-half as conductive as Swiggle Strip, and 6 to 11 percent as conductive as conventional aluminum spacers. Super Spacers are used by Pella in its Architect Series windows and by several smaller makers. Edgetech has also developed a hybrid spacer, which has yet to be adopted by a major manufacturer. In the new design, a conventional aluminum edge spacer is placed next to a nonmetallic Super Spacer.



MARIO FERRO

WARM EDGE: A HYBRID

Southwall Technologies of Palo Alto, Calif., has yet another design approach for window edge spacers. It will be used for its Heat Mirror glazing system that is to be introduced this year. In the Southwall warm-edge system, two steel spacers are separated by a $^{1}/_{8}$-inch-thick layer of rigid polyurethane foam. The same polyurethane thermal break is used in Southwall's top-efficiency Superglass with two suspended Heat Mirror films, a product that is used in Hurd's Insol-8 windows ["Windows of Opportunity," Dec. '89]. The conductivity of polyurethane foam is lower than that of silicone foam, boosting overall energy performance of a typical residential window by 20 percent, says Todd Sitrin of Southwall. He adds that there is also no outgassing with the warm-edge design.

They gobble power at the worst time, during the hottest part of the day—when power demand on electric utilities is at its peak and when the cooling system is at its lowest efficiency.

Thermal storage, in which cooling is created during off-peak hours for use later in the heat of the day, has long been used in large commercial buildings. Now Lennox Industries of Dallas is developing a residential system called CTES (for Cool Thermal Energy Storage). It will help utilities by leveling power-demand loads and save homeowners money by cooling during less expensive, off-peak periods, says Bill Dean, Lennox's research and development senior project engineer.

CTES adds two components to a conventional air-conditioning system: a refrigerant transport module (RTM) and a storage module. The RTM contains a pump, valves, and an electronic control board to manage the flow of refrigerant between the condensing unit (outdoor coil and compressor), evaporator coil (inside), and the storage module. The storage module has a large copper heat exchanger immersed in a tank of water.

During off-peak hours, the RTM valves will direct refrigerant to the storage module to freeze the water inside. If cooling is needed during off-peak hours, the system shifts from ice making to space cooling.

During peak hours, the condensing unit is turned off. When cooling is needed, the pump sends chilled refrigerant from the storage module to the indoor coil, where it boils into a gas and absorbs heat from the home. The refrigerant then recirculates to the storage module, where it is again condensed into liquid by the ice, dumping its heat.

Prototypes of the CTES units are now being tested in houses. The system will be introduced in a commercial-size version next year, followed in 1994 by a unit sized for residences. *—Evan Powell*

Gardening precautions

Your vegetable garden may be no Garden of Eden. The problem is commonly used pesticides, which can be absorbed through the skin. Chronic exposure to some pesticides through absorption has been linked with cancer; even occasional exposure can cause headaches or nausea.

Researchers at Pennsylvania State University found that small but measurable amounts of a common pesticide, carbaryl, lingered on the skin of home gardeners who had applied the

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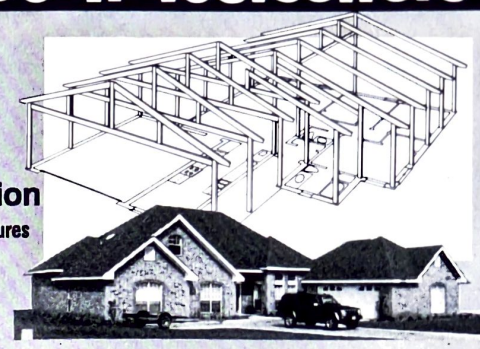

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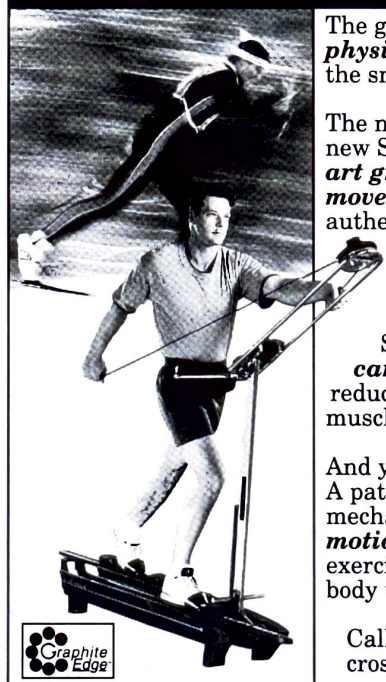

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MICROWAVE GARBAGE DISPOSAL

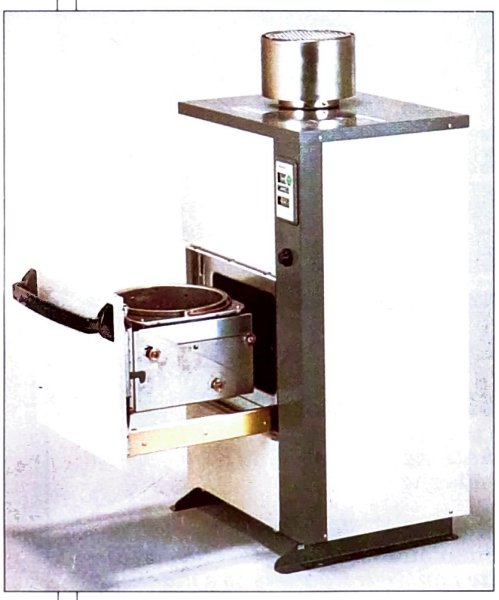
The idea of zapping matter into nothingness has long been a staple of science fiction. Now consumers in Japan can do that to their garbage: Matsushita Electric Industrial Co. has developed a microwave garbage incinerator for home and institutional use.

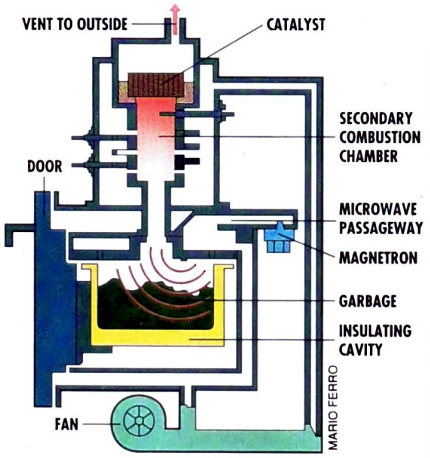
Essentially a souped-up microwave oven, the incinerator dries, burns, and then reduces the garbage to ash. Sensors and a controller vary the microwave output to suit each stage of the process. A secondary combustion chamber and a catalyst complete the burning of any gases so the device is nearly pollution-free (aside from the pollution created during electricity generation).

It takes the microwave incinerator more than four hours to incinerate 2.2 pounds of garbage, for example, reducing it to a pile of ash up to one-three-hundredths of the original weight. One such disposal cycle, however, consumes up to six kilowatt-hours of electricity.

Matsushita envisions local, small-scale use of the new device as part of a solution to the increasing difficulty of siting landfills and large incinerators in crowded Japan. Also, the Japanese authorities discourage the use of the in-sink disposals that are often used in the United States, fearing clogged sewers and overloaded waste treatment plants.

Matsushita is now shipping only samples of the microwave disposals to dealers, charging $3,830 for a 4.5-pound-capacity home unit and $50,000 for a 44-pound-capacity model. The company isn't currently planning to sell microwave incinerators overseas.—*Dennis Normile*





In Japan, consumers may soon use a garbage disposal that turns trash to ashes one three-hundredths of the original weight via microwaves.

chemical up to 20 days earlier. "Although it appears that gardeners are at little risk, this study can serve as a reminder that pesticides contain toxic materials and should be used with caution," says William Bode, one of the researchers. The group recommends harvesting home crops while wearing long-sleeved shirts, pants, gloves, shoes, socks, and an inhalation mask to minimize exposure to the residue of pesticides applied earlier in the season. Gardeners should also work upwind and avoid walking through sections that have been treated with insecticides until the spray is dry.

Cleaning the clothes worn to protect against pesticides isn't easy either: In a four-year study that employed chemical analysis and high-resolution electron microscopy, textile professor Mastura Raheel of the University of Illinois at Urbana-Champaign found that pesticide-contaminated clothes should be washed right away through three complete cycles to reduce chemical concentrations to safe levels. Also, if undiluted pesticides spill on clothes, Raheel advises, shower immediately and then burn, bury, or otherwise destroy the garments because even repeated washing will not clear them of unsafe residues.

Meanwhile, at Cornell University in Ithaca, N.Y., researchers have found that ordinary laundry starch on regular cotton and cotton-polyester clothing can help provide protection during pesticide application. The starch binds the pesticides to the clothing fibers, preventing the chemicals from reaching the skin; these chemicals can be released by washing the garments with soap and water.

Notes from home

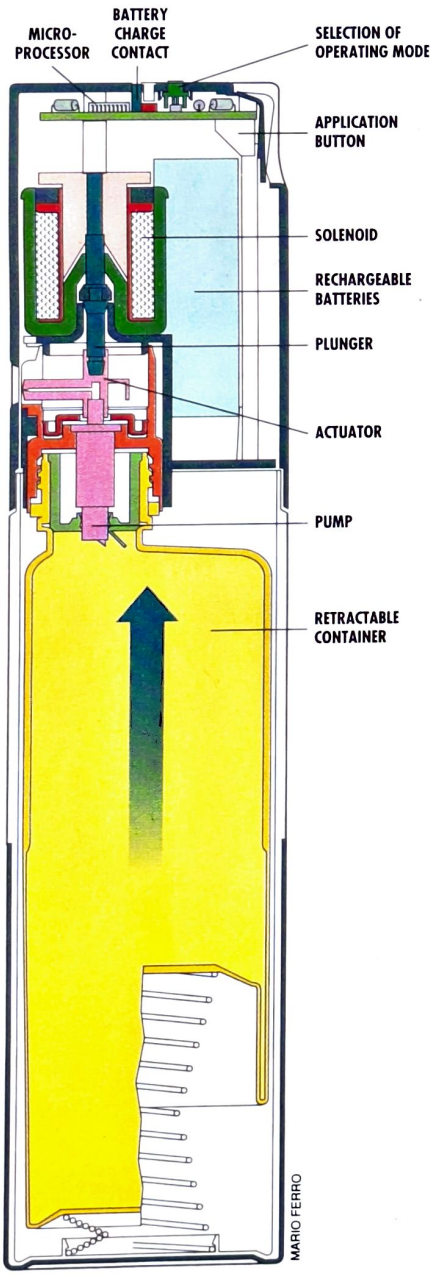
- The thermal bridge, a metal link that ups fluorescent bulb efficiency some 15 to 20 percent by draining excess heat, has been licensed to Lumatech Corp. for commercial development. The device was developed by researchers at Lawrence Berkeley Laboratory in Berkeley, Calif. ["HNF," May '91].
- Resell or donate. Trade in. Give to scrap dealers. These are some of the options discussed in a brochure on how to dispose of old power tools from the Outdoor Power Equipment Institute (341 S. Patrick St., Old Town Alexandria, Va. 22314). The free guide lists scrap recyclers and waste-management agencies that also provide information.
- Spred 2000 is an interior latex paint with a difference: It contains no petroleum-based solvents and releases no volatile organic compounds (VOCs). VOCs are reactive compounds that can help create smog and may be irritating when inhaled. The new paint, made by The Glidden Co. of Cleveland, will cost about the same as other premium-brand paints.
- Conserve one kilowatt-hour of electricity and you save 2.2 pounds of greenhouse-causing carbon dioxide from a coal-burning power plant, proclaims "Building an Environmentally Friendly House." The 40-page booklet, available for $3.75, describes building techniques, materials, and design to reduce a house's impact on the environment. Massachusetts Audubon Society Educational Resources Office, S. Great Rd., Lincoln, Mass. 01773.
- In 1991, the national rate of recycling steel ("tin") cans that are used to contain products such as food, beverages, paints, and aerosols increased by 38 percent over the 1990 rate, says the Steel Can Recycling Institute, an industry association in Pittsburgh. Today, about one in three steel cans is recycled.
- Ryobi America of Anderson, S.C., is the first to announce development of a gas-powered engine for hand-held outdoor power equipment that meets California's stringent emissions standards, scheduled to take effect in two tiers, in 1994 and 1999 ["Greener Pastures," July]. The cleaner-burning engine is to be in production by 1994; products incorporating the engine may cost 20 to 30 percent more than current ones, says Ryobi.

Non-propellant sprayer

Today's hair sprays, deodorants, air fresheners, and numerous other spray products use propane and butane gas propellants, which are highly flam-

mable and can also contribute to the creation of smog. Spray products, moreover, often must be shaken to activate these propellants, and lose propulsion when they are turned sideways or upside down. There is, however, an alternative.

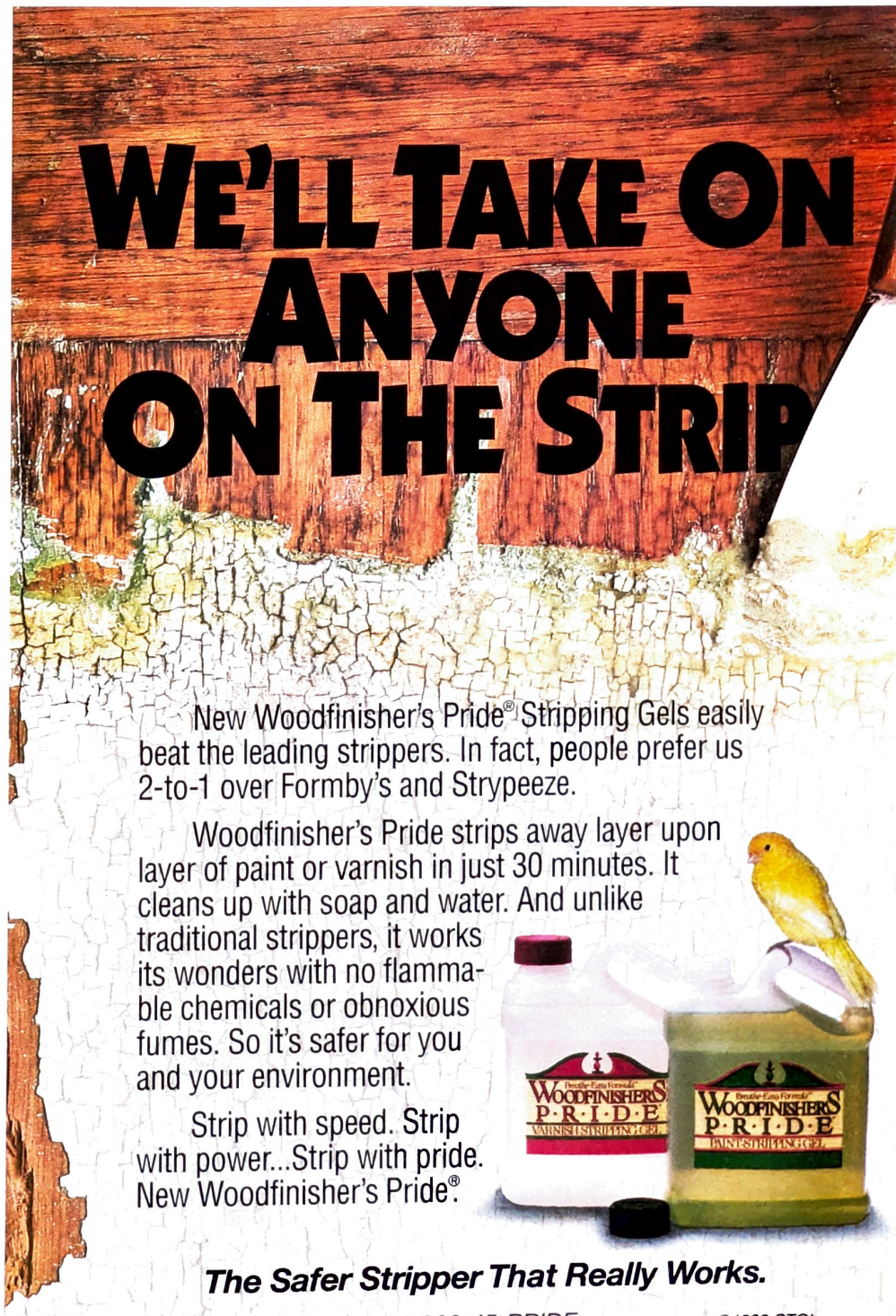
Yves Privas, a French chemical and physical engineer, has invented an electronically controlled spray device. In this system, a microprocessor activates a solenoid, which sets a pump into motion at a rate of 40 movements per second. The rapid motion of the pump vaporizes a product into 40- to 80-micron-size particles. Rechargeable batteries supply the power.



Instead of using propellants, a new sprayer employs a microprocessor-controlled pump to create the spray's fine mist.

With the application button depressed, the spray's force will remain constant for a full eight minutes—regardless of whether the device is held upright, upside down, or sideways. The spray can doesn't need shaking between applications because it doesn't use gas propellants. The products come in replaceable containers that are made of polyethylene. After a product is depleted, another refill container is put in its place.

The French cosmetics company l'Oréal will first sell the device in Europe this September. Helene Curtis and Procter & Gamble are currently testing it and are planning to manufacture the spray can in the near future. The list price will be about $40, but, explains Privas, "the system is less expensive in the long run compared with gas-propelled sprays since it only needs to be purchased once, and replacing the product in polyethylene containers is relatively inexpensive."—*Bruce Gain* PS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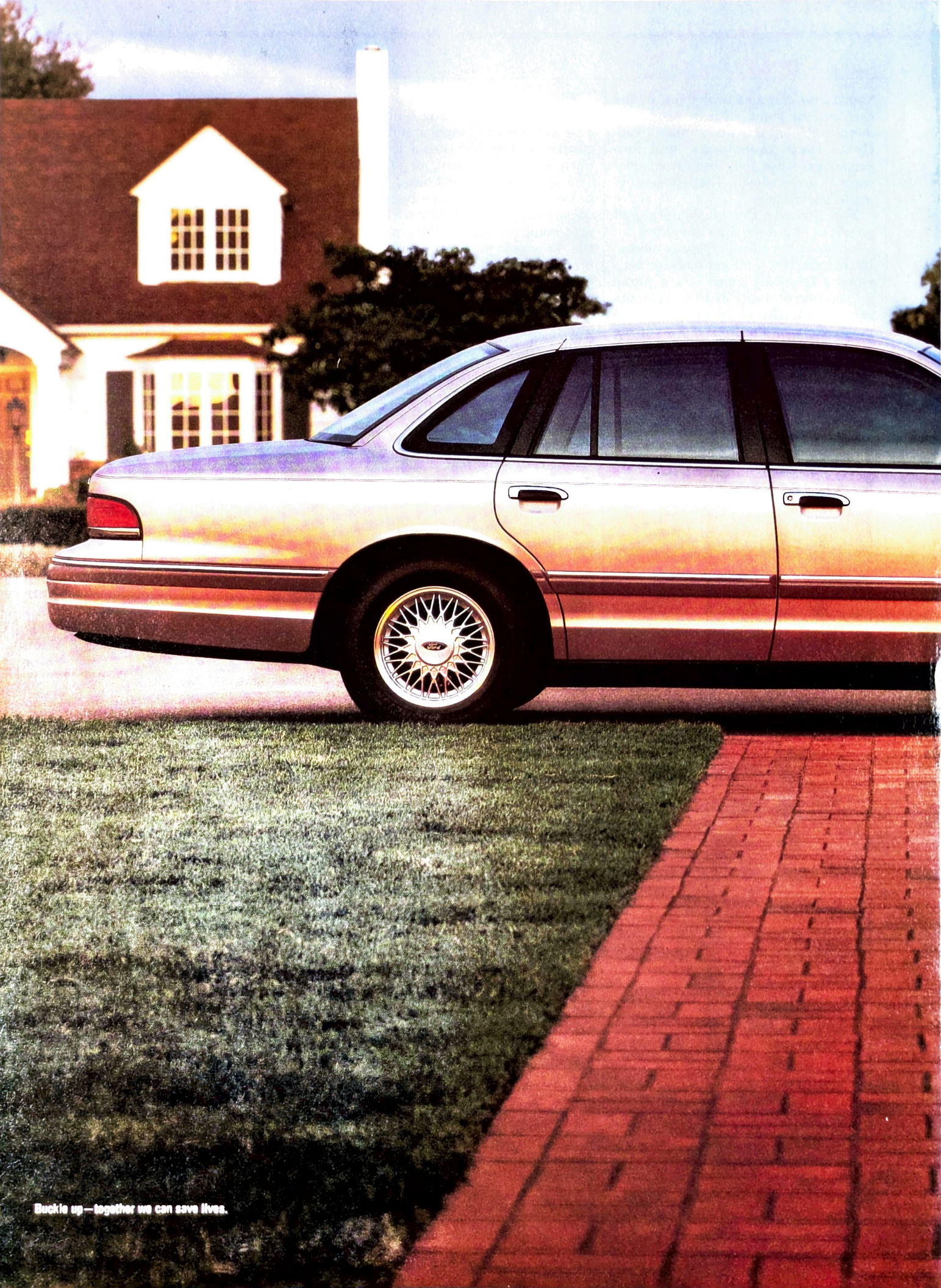
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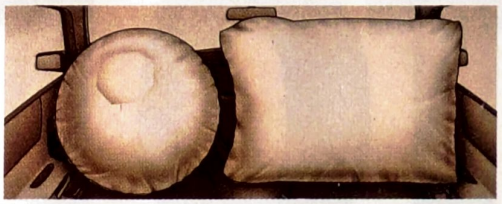

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HAVE YOU DRIVEN A FORD LATELY?

Ford

A half-century of nuclear bomb-making has left the U.S. with a nearly unmanageable quantity of nuclear waste. More than two-thirds of it is at Hanford near Richland, Wash. Only now have cleanup efforts begun in earnest.

BY DOUG GARR

TOO HOT TO HANDLE

Steel containers of waste are stacked for temporary burial to await a more permanent resting place.

PHOTOS BY JOHN B. CARNETT

A Westinghouse employee pulls our government car onto the road's shoulder in the "200 West" zone at Hanford Nuclear Reservation near Richland, Wash. He says, "There's the 101-SY tank." Two adjacent, narrow towers, each about 100 feet high, mark the spot. "Those are the lightning rods," he says.

Tank 101-SY, a gigantic steel-wall vat containing nuclear waste, has become synonymous with the problems that beset Hanford. Of the site's 177 underground storage tanks housing 65 million gallons of radioactive waste, 101-SY is among the most hazardous. It has one million gallons of sludge with a viscosity roughly equivalent to peanut butter. And within that sludge are 48,000 grams of deadly plutonium. Even though the 75-foot-diameter cylinder has a relatively modern, double-shell design, it's known as a "hot" tank because of its volatile mixture of hydrogen and oxides of nitrogen.

Temperatures rise due to the heat produced as the tank's radioactive contents decay. In addition, every three months or so, the pressure in 101-SY builds up to a point where a

hydrogen bubble vents. Enough pressure results from this bubbling to raise the level of the sludge by as much as a foot. This outgassing works its way up through the sludge and the two- to ten-foot crust that tops it. After such an event, called by some the "boom du jour," temperatures in the tank drop. After 101-SY exhaled in May 1991, for instance, officials were able to take a crust sample and install a remote video camera to allow for continual surveillance because of a sufficient release of hydrogen, which is highly flammable. Although the possibility of explosion from any kind of spark is slim, the contents of the tank and its gases are highly flammable and volatile, especially due to the presence of nitrous oxide.

For nearly five decades, the government has been building and stockpiling nuclear weapons with little awareness of what to do with the highly toxic byproducts routinely created by the continual refining and manufacturing of uranium and plutonium. As a result, nuclear reservations such as Hanford have become overstressed radioactive landfills.

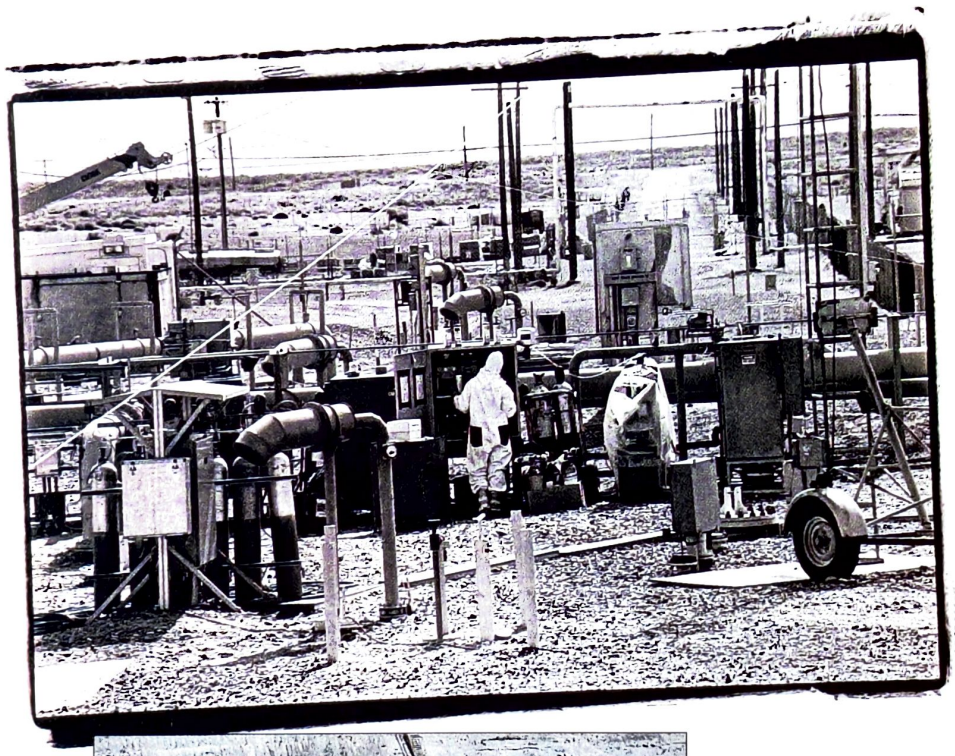
Hanford's current budget was set at $1.4 billion, its highest ever, with $783 million allotted for various cleanup activities. That may seem like substantial funding, but there are years of damage to undo. Various projects, such as the construction of more underground vaults, treatment of soil around leaking drums, waste sampling, and testing, all call for a piece of the pie.

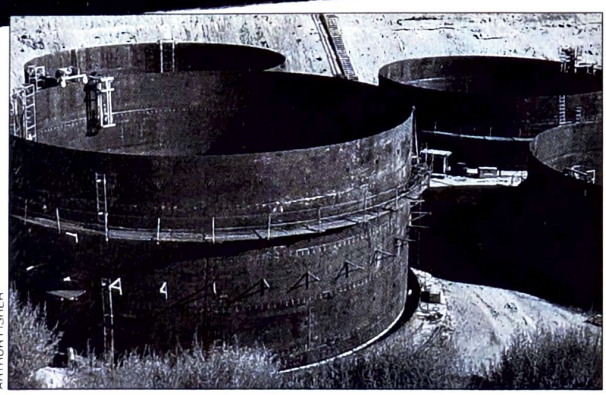
The weapons complex at Hanford was designed primarily to generate plutonium for the nation's nuclear arsenal. The plant used a process called PUREX (for Plutonium Uranium Extraction) to extract plutonium and sometimes uranium from irradiated reactor fuel. The extraction of one kilogram of plutonium by this process creates more than 340 gallons of highly radioactive waste and more than 55,000 gallons of low- to intermediate-level radioactive waste. The government has generated 100,000 kilograms of plutonium for the weapons program. Further, all along the way to building bombs, radioactivity has contaminated tools, machinery, paper products, employees' protective clothing, plastic sheeting, and other equipment.

The nuclear industry classifies waste on three different levels, all of which are harmful. The first is low-level waste, which usually contains small amounts of radioactivity in a large amount of material. Its radioactivity dissipates in a relatively short period of time, anywhere between 500 and 600 years. The second form is known as mid-level, or transuranic, waste, containing man-made elements heavier than uranium—hence the name trans- (or beyond) uranic. It consists mostly of contaminated materials in both liquid and solid forms. In addition to plutonium, it also contains radionuclides, which have half-lives of up to 250,000 years. The third category is high-level waste—highly concentrated levels of plutonium syrup and other very toxic nucleotides, which can kill quickly if they leak into the environment.

Basic methods of waste storage in the past were designed to fit the perceived risk level. Low-level liquid waste, for instance, had been dumped into man-made ponds. Until 1970, mid-level waste had been heaped into long, shallow trenches and covered with dirt. High-level waste had been stored in single-shell steel tanks.

What seemed reasonably safe in the 1940s and 1950s has become unacceptable by today's standards. Today, mid-level waste is put into steel drums or boxes and then buried. High-level waste is now poured into double-shell tanks. The theory here is that if the inner wall erodes, the waste will be contained by an equally strong outer wall.





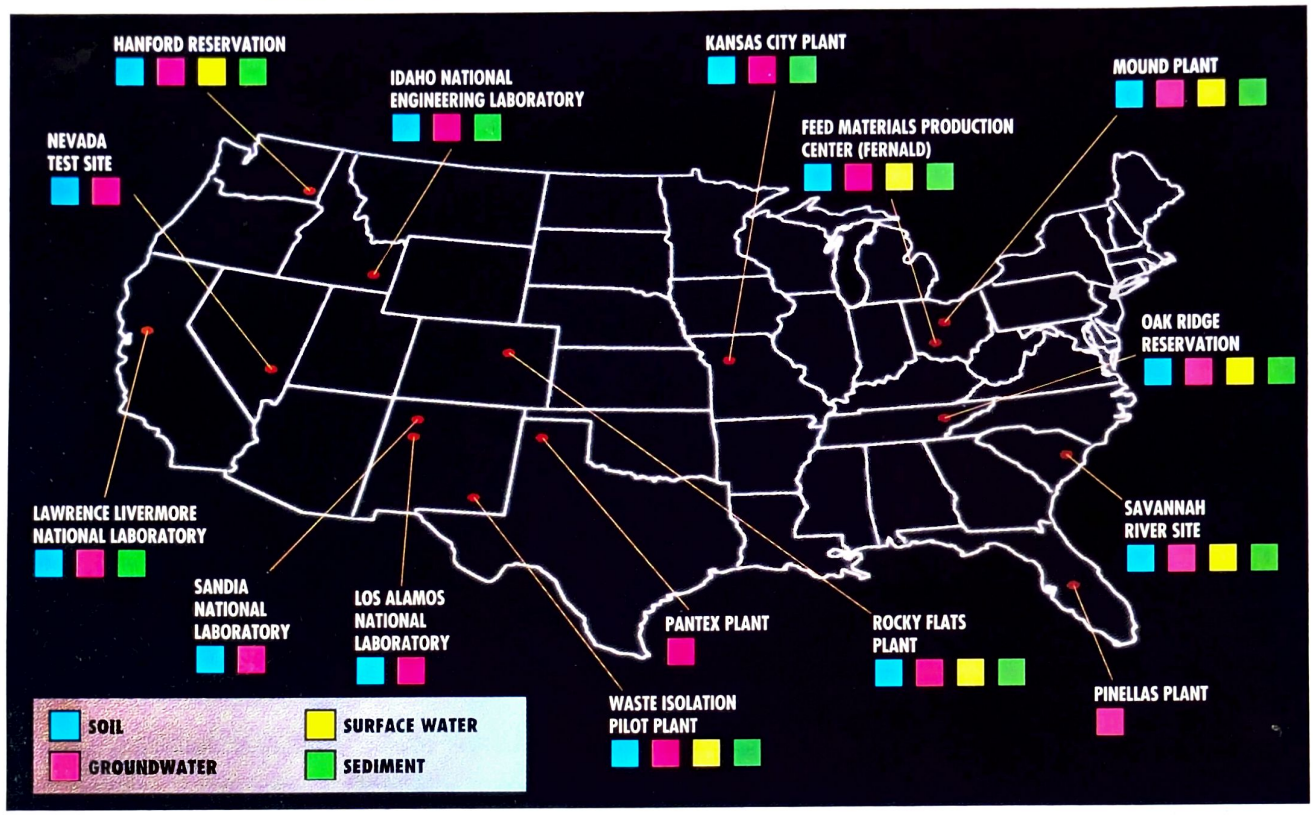
ARTHUR FISHER

Technicians work atop Tank 101-SY (top) amid lightning rods, vents, and testing equipment. The tank regularly makes its presence known by discharging hydrogen. Double-walled tanks (above) were constructed in the late 1970s, each with a capacity of a million gallons.

The Cold War weapons effort worked full tilt until the 1980s and did not, in fact, begin to abate until late last year. Nobody ever dreamed three to four decades ago that the United States would produce so many weapons and such massive amounts of waste. "We do know that at least 1.2 million cubic yards of the [Hanford] waste contain radioactivity," states literature issued by the Department of Energy (DOE). This quantity would cover the area of a football field to a depth of 700 feet.

Nearly two-thirds of the nation's high-level waste is at Hanford. But these estimates are thought to be the minimum figures because quantifying these wastes, which have accumulated as a result of various processes, often with incomplete record-keeping, is difficult at best.

THE NATION'S NUCLEAR WEAPONS COMPLEX



TOM MOORE

The Department of Energy (DOE) currently is reviewing the status of its 15 sites that make up what is referred to as the Nuclear Weapons Complex. Each facility is in a state of flux, as cleanup problems surface and the nation winds down its arms building and stockpiling. For instance, materials production has been shut down at Hanford Nuclear Reservation and Fernald. But the facilities will remain open in that a cleanup program has been initiated.

At least a dozen different radionuclides plus other toxic materials have been identified in the ground and water at the various sites. Groundwater contamination exists at every site, and the soil at every facility (except Pinellas and Pantex) needs to be cleaned up. Sediment problems exist at nine sites. In addition, off-site contamination of some kind can be found near nine of the 15 DOE facilities.

DOE officials have acknowledged that cleanup of many of these sites could take 30 years. They add that some facilities could remain contaminated for as long as a century. The department would like to spend $38 billion over the next five years as part of its "Environmental Restoration and Waste Management" plan.

Estimates within the DOE for the 30-year cleanup are in the $100 billion range. Many critics contend that at least twice that much will be necessary. Some suspect legal action on the part of the EPA might be necessary to finally get the job done.

TYPE OF FACILITY	FACILITY	STATE	SIZE (SQ. MI.)	EMPLOYEES
WEAPONS RESEARCH AND DESIGN	LOS ALAMOS NATIONAL LAB	NM	75	7,400
	SANDIA NATIONAL LAB	NM	62	8,500
	LAWRENCE LIVERMORE	CA	12	8,500
MATERIALS PRODUCTION	HANFORD PLANT	WA	570	13,500
	SAVANNAH RIVER SITE	SC	300	20,000
	FERNALD	OH	0.2	1,000
	IDAHO NATIONAL ENGINEERING	ID	893	10,500
WEAPONS MANUFACTURING	ROCKY FLATS PLANT	CO	14	6,000
	OAK RIDGE RESERVATION	TN	58	16,500
	MOUND PLANT	OH	0.3	2,400
	PINELLAS PLANT	FL	0.2	2,000
	KANSAS CITY PLANT	MO	0.5	7,800
	PANTEX PLANT	TX	14	2,800
NUCLEAR TESTING	NEVADA TEST SITE	NV	1,350	8,400
WASTE DISPOSAL	WASTE ISOLATION PILOT PLANT	NM	16	650

To appreciate the legacy of atomic weapons production, it helps to understand the secret early years of Hanford and the nuclear culture that was subsequently bred. Before the booming business of bombs, this area was virtually uninhabited. In 1943 the population was 240. Then came the military men who were charged with the responsibility of building a nuclear bomb in haste and secrecy as part of the Manhattan Project. By the middle of 1944, approximately 50,000 people were working at Hanford. During the project, Hanford processed plutonium for "Little Boy," the nuclear bomb that devastated Nagasaki, Japan, in 1945.

After the war, the town of Richland, just south of Hanford, grew and was nourished by the ongoing Cold War weapons industry. Today, thousands of employees, mostly from Westinghouse, the government's major contractor here, work in some capacity for the nuclear industry. Hanford is home to nine moribund nuclear reactors. There is a fast-flux test reactor not currently in operation, and there is also a civilian nuclear power plant operated by the regional utility.

In the town of Richland, despite the controversy surround-

ONE SOLUTION: GLASSIFICATION

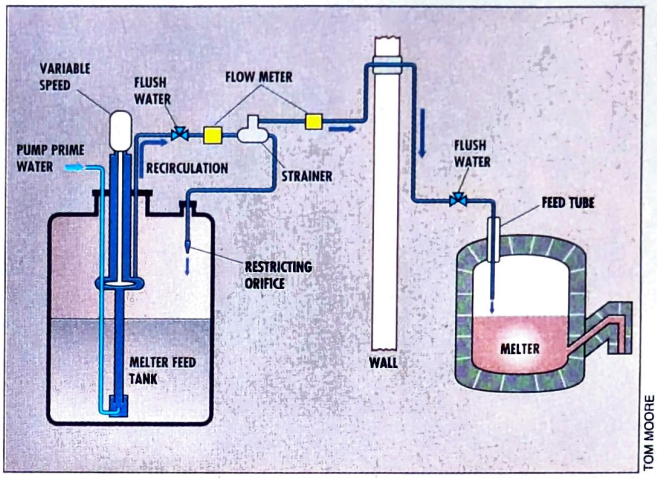
As classified by the Department of Energy, the high-level wastes at Hanford are highly radioactive, are best handled by remote control from behind protective shielding, and require permanent isolation. By 1995, Hanford Nuclear Reservation in Washington will have 28,000,000 gallons of such wastes stored in underground double-shell tanks, according to site manager Westinghouse Hanford Co.

To attempt to dispose of it they will build, for completion in 1999, the Hanford Waste Vitrification Plant. Battelle's Pacific Northwest Laboratory has designed technology that will vitrify, or turn to glass with heat and fusion, a substantial portion of high-level waste. Concentrated liquids are expected to be reduced by 75 percent and combustible wastes to 10 percent of their original volume by the process. Borosilicate glass, the end result of the process, will be fed into stainless steel canisters that will be deposited in federal geologic depositories.

According to Westinghouse, pretreatment of these high-level wastes will permit 2,000,000 gallons to be vitrified. The remainder will be reclassified as low level, treated at the on-site Grout Treatment Facility, and stored in near-surface vaults at Hanford.

"Feed," or waste, is concentrated, glass formers are added, and it is then further concentrated in an evaporator. It is then transferred to the melter feed tank, which regulates feed to the melter at a rate of 220 pounds per hour.

Radioactive wastes are highly combustible, causing them to decompose in the high temperatures of the melter. The waste is introduced to the melter below a pool of molten glass. As wastes turn to ash, they are quickly immobilized within the glass, which is fed directly into canisters and sealed.



The entire operation is to be handled remotely, including maintenance. A number of points along the process cause the release of gases including particulates, chemically reactive gases, and radionuclides. An effluent treatment system is included in the plant to handle such releases.

Glass wastes are considered to be stable, and it is hoped, according to Battelle, that they will be classified as nonhazardous, inert material. Battelle envisions that such material would be suitable for disposal at landfills.

ing radioactive waste, remnants of the nuclear culture still exist. You can find Proton Lane and Nuclear Lane, get your car repaired at the Atomic Body Shop and Towing, or bowl a few games at the Atomic Lanes. The local high school football team is nicknamed the Bombers, and its logo features a mushroom cloud. When the nuclear waste controversy began simmering, the students reconsidered and put the nickname to a vote. They elected to keep it.

In its days of full production, Hanford was the nation's first and busiest production site (with the exception of Los Alamos in New Mexico, which has always been primarily a research facility). It's the site that helped win the war, but, according to a General Accounting Office inspection, Hanford has led in violations of 9 out of 24 safety and health categories and was cited for 17 percent of the problems at 18 DOE sites, more than any other.

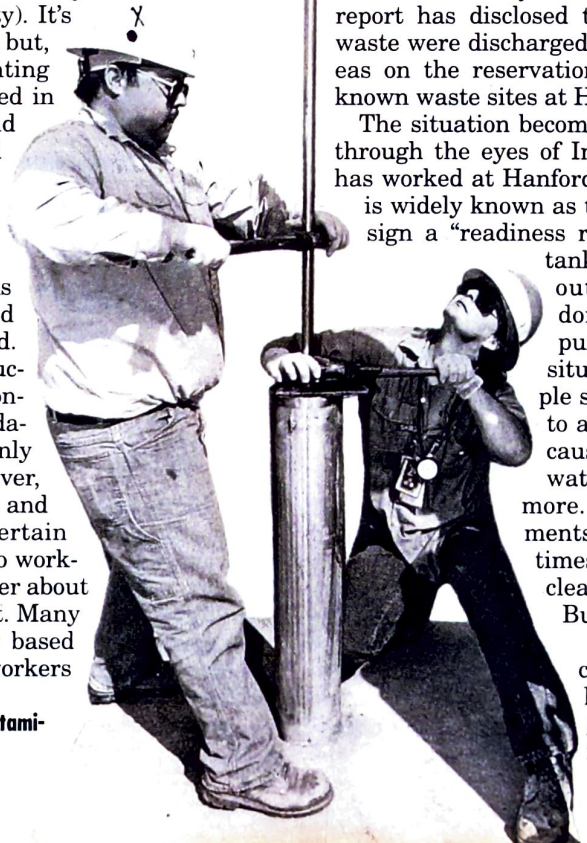
At least 66 of Hanford's 149 first-generation, single-shell tanks constructed between 1944 and 1966 are known to have leaked. Because the U.S. weapons production program was necessarily conducted in hurried secrecy, early data, often hastily compiled, has only recently been made public. Moreover, the record-keeping was sketchy, and officials today aren't exactly certain what the tanks contain. Years ago workers didn't count anything or wonder about whether to dump materials or not. Many of today's estimates are actually based on interviews with these early workers who still live in the Hanford tri-cities area. "We have a Hanford retirees' association," says Bill Klink, a former Westinghouse spokesman, now retired himself, "and often that's how we find out what's in there."

The nature of the waste remains in considerable doubt. "Given 30 years, a lot of different chemical reactions have taken place," says Bob Cook, a physicist and nuclear engineer formerly with the Nuclear Regulatory Commission, who adds, "they don't really know exactly what's in those tanks."

Beyond what is contained in these storage vats, some waste was merely dumped in a haphazard fashion. A DOE report has disclosed that 678,000 curies of radioactive waste were discharged directly into the ground at 619 areas on the reservation. There are approximately 1,500 known waste sites at Hanford; there may be others.

The situation becomes that much clearer when viewed through the eyes of Inez Austin, a senior engineer who has worked at Hanford for more than a dozen years. She is widely known as the on-site engineer who refused to sign a "readiness review" for the pumping of a new tank. The forms were improperly filled out, the preparatory work wasn't done, and the tank was unsafe to pump, she concluded. Of the general situation she says, "We can't even sample some stuff because it has to be sent to another facility. We can't ship it because it's too hot. And if we cool it with water to ship it, it's not the same anymore. We've set up all these requirements, and we can't meet them. A lot of times we just see a hot spot, and we clean it up, and we put it in a drum. But then what do we do with it?"

Long-term burial in deep geological repositories seems to be the most likely solution, but recent efforts to gain approval have been slow-moving. It will take years for the politi-



Monitoring the aquifer for radioactive contamination is an ongoing pursuit at Hanford.

cal difficulties to be worked out, since no community wants to accommodate nuclear sludge. Nevertheless, the idea itself appears to be technically sound: Put transuranic and high-level waste into vaults a half-mile-deep underground in remote areas of the country where they would be safely out of the way for at least 10,000 years. It's not forever, but it's certainly preferable to steel drums, which deteriorate in 30 or 40 years. Congress has designated two sites for this purpose—one in Yucca Mountain, Nev., for high-level waste, the other near Carlsbad, N.M., for transuranic waste. Yucca Mountain isn't scheduled to be ready until 2010 at the earliest. The Carlsbad site, known as WIPP (for Waste Isolation Pilot Plan), has been met with staunch local opposition. The state of New Mexico, in fact, sued the DOE—it was a case of "NIMBY," or the syndrome popularized as "not in my backyard"—and won a temporary injunction in federal court last November. The DOE is appealing, but it is also quietly sending out feelers for other sites.

Finding alternate sites won't be easy. The New Mexico area was selected because geologists already knew a lot about the terrain. It is limned with deep salt beds, which are considered to be appropriate, naturally occurring containers for the most dangerous types of radioactive material, including those whose constituency is not entirely known. Scientists are somewhat less sure of the Nevada site's geological merits, so they suggest putting somewhat less threatening radioactive waste there.

The deep-burial approach is still far from being a definite solution. The first deposits will be viewed as experimental. If the DOE wins its appeal and gets the New Mexico WIPP site approved, it isn't scheduled to begin depositing waste there until 1997. The plan calls for 4,500 drums of transuranic sludge—about 0.5 percent of its capacity—to be put in "rooms," or mines, 2,100 feet underground. Then a five-year evaluation program begins. The EPA will set federal environmental standards, and the DOE will be required to meet them. "For the higher level waste, it's going to be a number of years before there are going to be approved sites," says Bill Gunther, director of the Criteria and Standards Division, Office of Radiation Programs, at the EPA. "And if the site proves unsuitable, then they'll have to take the waste out." Ultimately, if deep burial comes to be recognized as an acceptable long-term solution, many other hurdles associated with safely transporting nuclear waste through communities will have to be negotiated.

Official estimates for cleaning up Hanford alone suggest it will run at least $30 billion and as high as $57 billion over a 30-year-period. Critics, including the government's own Office of Technological Assessment (OTA), believe those estimates are way too low. "Without knowledge of the cleanup levels to be achieved by the end of 30 years, or the technologies required to achieve such levels, the DOE cannot develop reliable cost estimates for the total cleanup," states an OTA report.

"Clearly, we're not going to get every molecule out of the ground here," says Ron Bliss, a vice president at Westinghouse, formerly in charge of environmental restoration at Hanford. "The question is, 'How clean is clean—what's environmentally safe?' "

Aside from long-term deep-burial disposal, most technical solutions involve unproven or vastly expensive processes—such as *in situ* vitrification, a method of solidifying the waste into glass—that will take years to perfect. Though it is in limited use in other countries, right now vitrification is merely a signpost and an overgrown, grassy site at Hanford. The first glassification plant will cost $1 billion, and it won't begin processing waste until 1999 (see One Solution: Glassification). There is also some speculation that transmutation—bombarding high-level waste with nuclear particles to nullify their long half-lives—is a possibility. But transmutation is still in the debate and laboratory development stage.

Meanwhile, the radioactive waste piles up, even as our weapons production is expected to reach an all-time low in the next few years. The quantities are difficult to determine because, according to the DOE, nuclear bomb manufacturing is classified, but it is known that commercial reactors are spewing out 2,000 metric tons of uranium as spent fuel each year.

"Will the other single-shell tanks leak in the future?" asks Paul Day, the Hanford EPA project manager. "Yes," he concludes. "They were designed to last for 30 years, and some are approaching that age now." Admits Ralph Wahlen, an on-site plant manager for Westinghouse at Hanford, "There are probably some tanks that we don't know about that have leaked."

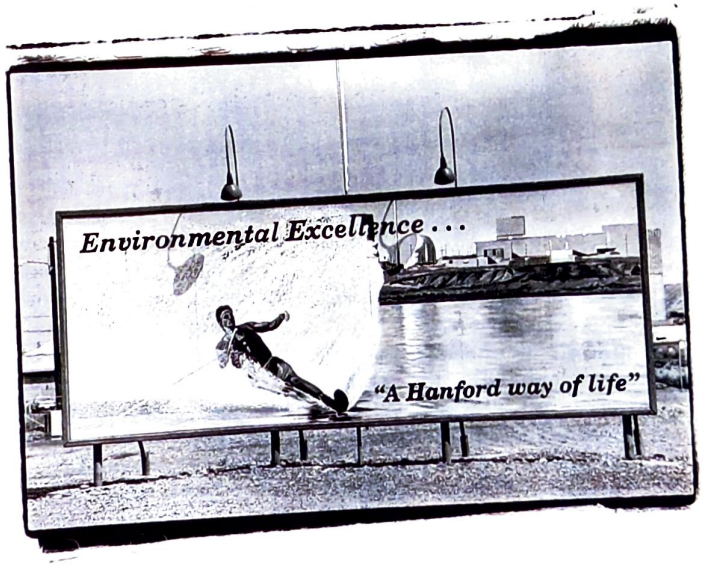
There are far too many unanswered questions at this time to make anyone involved in nuclear waste management comfortable or optimistic. "Even while they're cleaning some areas," says Allen Conklin, an official with the Washington State Department of Health, "there are others that are becoming contaminated. It's like one step forward, one step backward."

The future rate of nuclear waste production is difficult to predict. Even as we pledge to build fewer nuclear weapons, there's a strong likelihood that the new breed of civilian light-water reactors will be providing megawatts of electricity soon—and its share of radioactive waste.

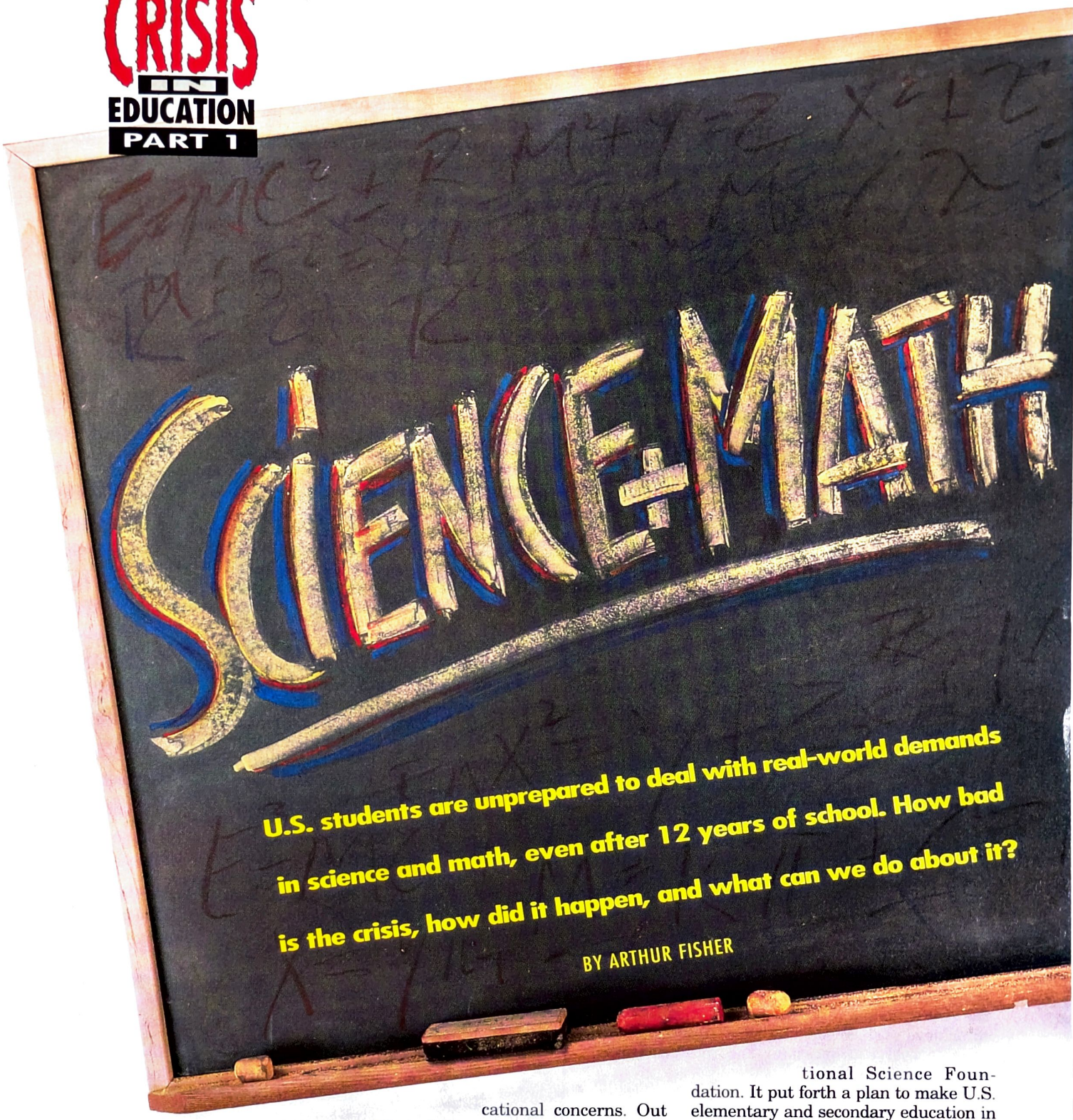
The health costs, in dollars and human suffering, are somewhere between huge and incalculable. Not only has the tank waste leaked, but large amounts of radioactive material at Hanford were deliberately released into the atmosphere, sometimes at staggering rates. Although the DOE fervently denied doing so for years, in the 1940s and 1950s there were regular releases of radioactivity, both accidental and intentional. Smokestacks were originally unfiltered, so harmful radionuclides were routinely blown across the plains. Cows grazing on adjacent farmland absorbed radiation by eating grass, and it's estimated that 20,000 children drank contaminated milk.

To put the situation in perspective, children at the Chernobyl catastrophe in the former Soviet Union were exposed to 120 rems of radioactive iodine. Children in Pasco,

[*Continued on page 110*]



CRISIS IN EDUCATION PART 1



U.S. students are unprepared to deal with real-world demands in science and math, even after 12 years of school. How bad is the crisis, how did it happen, and what can we do about it?

BY ARTHUR FISHER

President Bush, in September 1989, convened an education summit of eminent educators along with the governors of all 50 states in historic Charlottesville, Va. Here, at the university that Thomas Jefferson designed according to his personal beliefs in the sanctity of learning, the delegates confronted the gamut of the nation's educational concerns. Out of their deliberations came a set of six National Education Goals, approved by the National Governors' Association and seconded by the president in February 1990.

Goal 4 was the most dramatic: "By the year 2000, U.S. students will be first in the world in science and mathematics achievement."

For those with long memories, that dictum eerily echoed one that had been issued in 1983 by the National Science Board, the governing body of the National Science Foundation. It put forth a plan to make U.S. elementary and secondary education in science and math "premier in the world by 1995, as measured by achievement scores and participation levels," claiming that otherwise, "the nation that dramatically and boldly led the world into the age of technology will fail to provide its own children with the intellectual tools needed for the 21st century."

That followed on the heels of a report by the U.S. Department of Education titled "A Nation at Risk." It stated that "the educational foundations of our society are presently being eroded by a

BY HAND DESIGN

rising tide of mediocrity that threatens our very future as a nation and as a people." Of particular concern, the report held, was the low estate of science and mathematics education. If a foreign power had brought our educational system to such a pass, the report thundered, the action would have been grounds for a declaration of war.

Things have not gotten significantly better. Science performance declined in the '70s, improved somewhat in the '80s, but in 1990 was at the same level for 9- and 13-year-olds—fourth- and eighth-graders, respectively—as it was in 1970. For 17-year-olds—twelfth graders—scores were actually lower than in 1970. Indeed, the extent of scientific and mathematical illiteracy in the United States is appalling, and there now exist more than 300 reports to attest to that fact. They provide an insistent and doleful drumbeat of depressing numbers.

Far from being "first in the world," U.S. students rank near the very bottom of the industrialized nations in science and math achievement.

In March of last year, about 175,000 9- and 13-year-old students from 20 countries took standardized tests in science and math. The exams, administered in 13 languages by the Educational Testing Service of Princeton, N.J., were part of the second International Assessment of Educational Progress.

Released this past February, the results were not a surprise, but were no less shocking for that. In almost every category, 13-year-olds in the United States ranked among the lowest of all those taking the tests—lower than students from Korea, Israel, Spain, Hungary, Slovenia, and the former Soviet Union. (Germany and Japan were invited to participate, but declined.)

Fifteen of the 20 countries involved tested more or less representative samples of their students, so it is fair to see how the U.S. students did compared with this group. The Americans flunked the science test—taking thirteenth place, ahead of Ireland and Jordan. Number one? Korea, followed by Taiwan, Switzerland, Hungary, the former Soviet Union, Slovenia, Italy (the Emilia-Romagna region only), Israel, Canada, France, Scotland, and Spain.

In math, the 13-year-olds from the United States did even worse—landing in the next-to-the-bottom slot, with Jordan last. The first five places were again occupied by Korea, Taiwan, Switzerland, the former Soviet Union, and Hungary. To put this in some kind of perspective, Korean 13-year-olds are twice as successful as their American peers at solving two-step arithmetical problems, such as determining an average by adding a series of items and then dividing by the number of terms.

What is even worse is the way the very best U.S. students—the top 10 percent—compared with the best students in the other countries. Said Secretary of Education Lamar Alexander after the test results were released: "The survey shows, first, that our best students can compete with the best students in any country . . . ." And an accompanying statement from the Educational Testing Service said that "the top 10 percent of American students compare favorably with the top students from other countries in both math and science."

Both statements are demonstrably false, says Lawrence Feinberg of the U.S. National Assessment Governing Board: "Actually, when compared with the same top slice of students in the 15 countries that tested representative samples of their population, the top 10 percent of U.S. students rank near the bottom for 13-year-olds in both math and science. That's where the average scores for the U.S. rank too."

For the top 10 percent of 13-year-olds in math, for example, the scores range from 63.5 percent correct for Jordan to 97.3 percent correct for Taiwan. The U.S. score is 82.7 percent correct, placing it twelfth out of 15, Feinberg says, "behind every other economically developed country on the list except Spain."

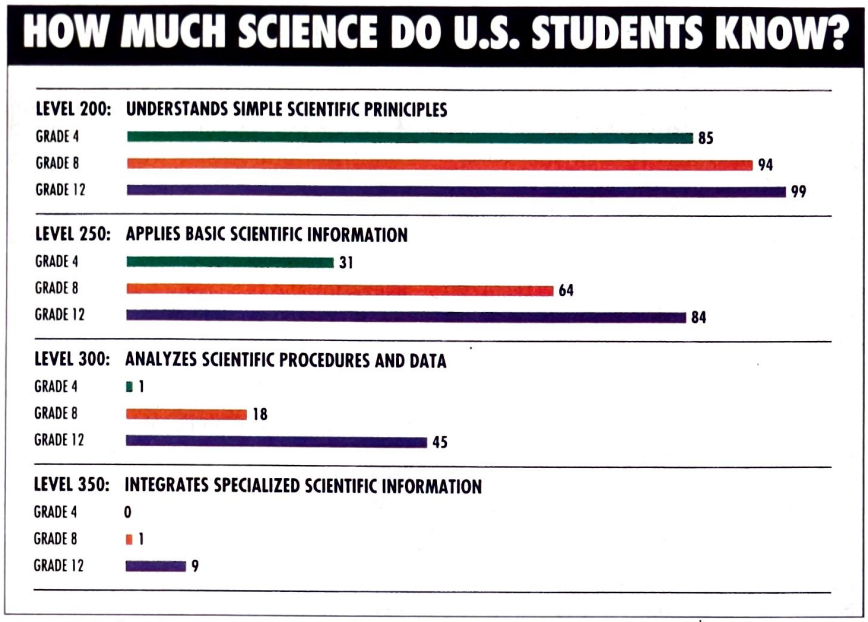
Some studies show that a math performance gap between American children and some Asian children exists even at the very start of formal schooling. James W. Stigler and Harold W. Stevenson of the University of Michigan studied the math scores of American, Japanese, and Taiwanese children over a ten-year period. They report that for some reason the Asian students' performance was better than the Americans' even in first grade, and that as the children grew older, the gap widened progressively.

Perhaps we pay too much attention, some critics say, to the "horse race" aspect of foreign competition. How well do American students meet our own expectations for science and math achievement?

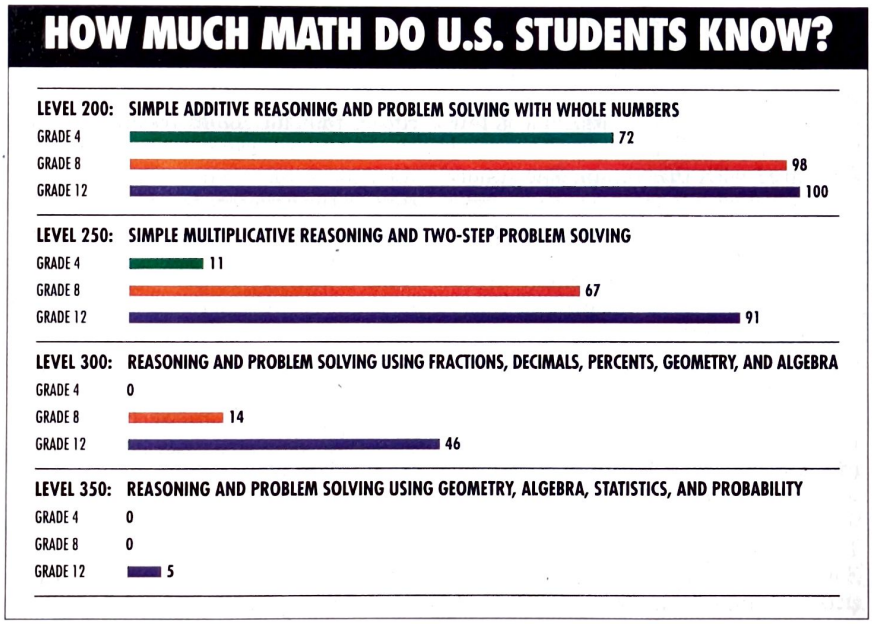
That question is answered every four years by a nationwide test that has been given since 1969 as part of the National Assessment of Educational Progress (NAEP), a congressionally mandated program. Known less formally as "The Nation's Report Card," it is the only continuous evaluation of what American students know in various subject areas.

The 1990 Science Report Card, released this past March, is based on a test given to nearly 20,000 students from grades 4, 8, and 12 in every state of the union. (The third goal of the president's "America 2000" program is to ensure that each American student leaving these grades can demonstrate competence in core subjects.) The questions covered life science, physical science, earth and space science, and the nature of science itself. The test sought to reveal how well students in these three grades do at four levels of science proficiency (see top graph on following page).

The results reported are dismal. A fairly decent performance by fourth graders—most of whom perform at or


HOW MUCH SCIENCE DO U.S. STUDENTS KNOW?
LEVEL 200: UNDERSTANDS SIMPLE SCIENTIFIC PRINICIPLES
GRADE 4 85
GRADE 8 94
GRADE 12 99
LEVEL 250: APPLIES BASIC SCIENTIFIC INFORMATION
GRADE 4 31
GRADE 8 64
GRADE 12 84
LEVEL 300: ANALYZES SCIENTIFIC PROCEDURES AND DATA
GRADE 4 1
GRADE 8 18
GRADE 12 45
LEVEL 350: INTEGRATES SPECIALIZED SCIENTIFIC INFORMATION
GRADE 4 0
GRADE 8 1
GRADE 12 9

Percentage of students performing at or above science proficiency levels in grades 4, 8, and 12. A majority of seniors can't apply scientific knowledge to interpret tables and graphs.


HOW MUCH MATH DO U.S. STUDENTS KNOW?
LEVEL 200: SIMPLE ADDITIVE REASONING AND PROBLEM SOLVING WITH WHOLE NUMBERS
GRADE 4 72
GRADE 8 98
GRADE 12 100
LEVEL 250: SIMPLE MULTIPLICATIVE REASONING AND TWO-STEP PROBLEM SOLVING
GRADE 4 11
GRADE 8 67
GRADE 12 91
LEVEL 300: REASONING AND PROBLEM SOLVING USING FRACTIONS, DECIMALS, PERCENTS, GEOMETRY, AND ALGEBRA
GRADE 4 0
GRADE 8 14
GRADE 12 46
LEVEL 350: REASONING AND PROBLEM SOLVING USING GEOMETRY, ALGEBRA, STATISTICS, AND PROBABILITY
GRADE 4 0
GRADE 8 0
GRADE 12 5

CHARTS BY ELIOT BERGMAN

Percentage of students performing at or above math proficiency levels in grades 4, 8, and 12. Fewer than half of high school grads can cope with fractions and decimals.

above Level 200—deteriorates over the years, reaching the lowest levels by twelfth grade. Only 45 percent of the high school seniors performed at or above Level 300, and only a pitiful 9 percent could reach Level 350. "Especially considering the technological needs of today's society," the NAEP report concludes, "a disproportionately low percentage of these students possess in-depth scientific knowledge or the ability to accomplish even relatively straightforward tasks requiring application or thinking skills."

The Math Report Card for high school seniors also flaunts an F. Proficiency levels of the problems on the 1990 Math NAEP given to 126,000 students in all 50 states are shown in the graph above.

Based on their collective experience with what math is covered in U.S. elementary and high schools and how it is taught, a panel of eminent mathematics educators linked Level 200 with third-grade work, Level 250 with fifth grade, Level 300 with seventh grade, and Level 350 as content generally covered in high school courses preparatory to the study of more advanced math.

Here is what the NAEP Report Card says about the results of the national exam: "All the high school seniors demonstrated success with third-grade material. However, [only] 91 percent showed mastery of the fifth-grade course, indicating that not all students are graduating from high school with [even] a grasp of how to apply the four basic arithmetic operations to solve simple problems with whole numbers. Fewer than half . . . demonstrated a consistent grasp of decimals, percents, fractions, and simple algebra, and only 5 percent [even lower than in the 1986 NAEP] showed an understanding of geometry and algebra that suggested preparedness for the study of advanced mathematics.

"These figures show that many students appear to be graduating from high school with little of the mathematics understanding required by the fastest-growing occupations or for college work . . . .

"The mathematical skills of our nation's children are generally insufficient to cope with either on-the-job demands for problem-solving or college expectations for mathematical literacy. Because of the emergence of the importance of mathematics to so many areas of education, citizenship, and careers, business and industry spend billions in training, colleges and universities devote large amounts of time to remediation, and still the United States is having difficulty maintaining its competitive edge in the global marketplace."

In short, there is a math emergency in the nation's schools. As Secretary of Education Alexander responded, "This is an alarm bell that should ring all night throughout this country."

"We've all been led to believe that we are above average," said Francie Alexander, California's associate superintendent of schools at the time of the test, but now an assistant secretary of education in Washington, D.C. "These results should take care of that myth."

(Representative examples of science and math problems at Levels 300 and 350, drawn from the NAEP's 1990 Science Report Card and 1990 Math Report Card, appear later in these pages. Answers to the problems appear at the end of the article.)

For the first time, the 1990 NAEP assessed the individual performances of 40 states at the eighth-grade level. (State legislators had long resisted this kind of exposure for fear of a wave of voter antipathy.) The analysis turned up some striking disparities. The states whose eighth-graders had the highest levels of math proficiency were North Dakota, Montana, Iowa, Nebraska, Minnesota, and Wisconsin. Oddly, these states cluster at the northern edge of the U.S. map. This prompt-

ed a whimsical Sen. Daniel Patrick Moynihan of New York to write that because closeness to Canada was a better indicator of math performance than money spent per student, "disadvantaged states should establish summer capitals in the Thousand Islands of the St. Lawrence River." Less fey suggestions were that these conservative, mostly rural northern states have relatively stable populations, where a strong work ethic is prevalent. They are states with relatively high levels of two-parent families and of parental education; North Dakota ranks first among the states in parents who are college graduates—49 percent.

Montana students spend a lot of time reading, one state educator says, because there is nothing else to do. In fact, the six states had the lowest percentages of eighth-graders who watched television more than six hours a day.

One symptom of the general math malaise among the eighth-graders surveyed by the 1990 Math NAEP was the paucity of calculators and computers in the classroom, despite the fact that the use of these modern tools is a central plank of math education reforms. In all but three states, fewer than one-third of the eighth-graders in public schools were permitted unrestricted use of calculators, an apparent hangover of the antediluvian prejudice against the devices because they supposedly make things easier for students. And, says the Math Report Card, "In most states, large percentages of eighth-graders attending public schools reported never using a computer in mathematics class . . . . "

Both the math and science 1990 report cards reconfirm another disquieting trend that has long been apparent: the achievement gap of black and Hispanic students compared with white and Asian/Pacific Islander students. In math, the gap between these two groups looms large. For example, 70 percent of Asian/Pacific Islander high school seniors could handle fractions, decimals, percents, and simple algebra (Level 300); only 16 percent of the black twelfth-graders could. (Within the two groups, Asian students tend to outperform whites, and Hispanics tend to outperform blacks, but by much smaller margins.)

The Science Report Card shows similar lags, which become larger as the students grow older. Ninety-three percent of white fourth-graders could understand simple scientific principles (Level 200); 59 percent of black fourth-graders could. But by the twelfth grade, 53 percent of the white students could analyze scientific procedures and data (Level 300); only 12 percent of black students could. At Level 350 (which integrates specialized scientific information), where U.S. performance is abysmal overall, the ethnic gap is a chasm: 12 percent of whites perform at this level, while 1 percent of blacks do.

The results of the failure of science and math education are obvious both for the population as a whole and for the lagging minorities. More than 50 percent of high school students abandon science courses as soon as they can. Only 40 percent of high school graduates have taken chemistry; only 19 percent have taken physics. This is not surprising considering that 29 percent of the nation's high schools have no physics teacher, 17 percent no chemistry teacher, and 8 percent no biology teacher, according to a survey conducted by the National Science Teachers Association. Seventy percent of our high schools don't offer courses in earth or space science.

More than one-third of seventh- and eleventh-graders find their science classes "boring," and

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2. **If you answered yes, what grade is your child in?**
3. **Are you satisfied or dissatisfied with the quality of science education?**
4. **Are you satisfied or dissatisfied with the quality of math education?**
5. **Do you favor or oppose nationwide curricula in science?**
6. **Do you favor or oppose nationwide curricula in math?**
7. **Do you agree or disagree that more advanced technology such as computers and lab equipment would make a difference?**
8. **Do you agree or disagree that better trained science and math teachers would make a difference?**
9. **Would you be willing to pay more in taxes to provide better science and math education?**
10. **Please indicate your own level of education.**
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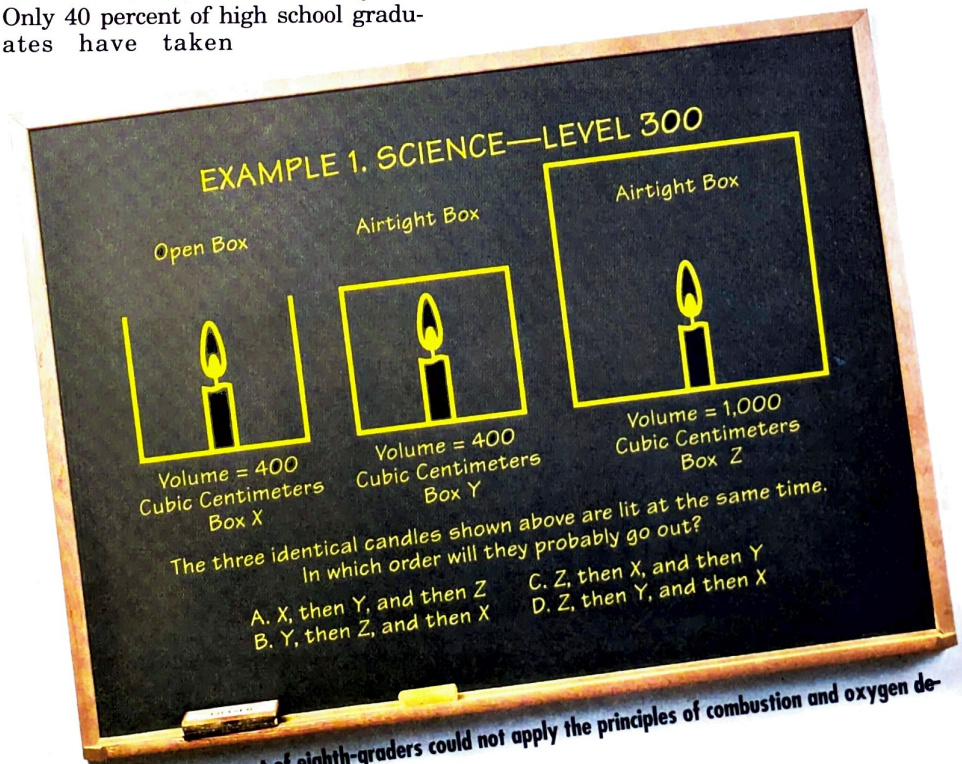
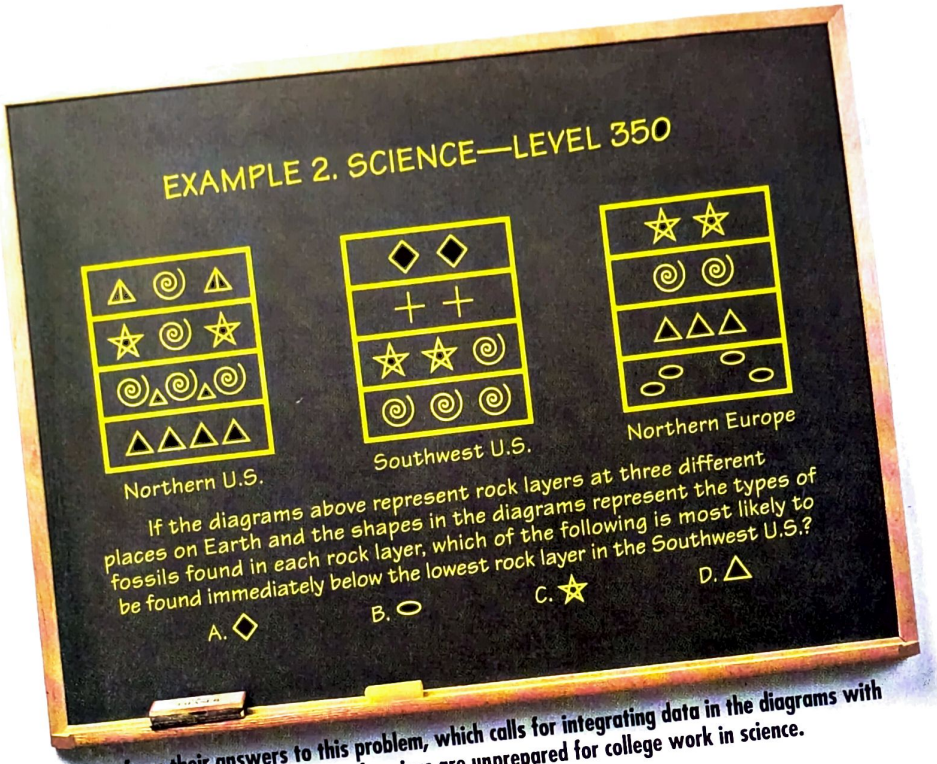

EXAMPLE 1. SCIENCE—LEVEL 300
Open Box
Airtight Box
Airtight Box
Volume = 400 Cubic Centimeters Box X
Volume = 400 Cubic Centimeters Box Y
Volume = 1,000 Cubic Centimeters Box Z
The three identical candles shown above are lit at the same time. In which order will they probably go out?
A. X, then Y, and then Z
B. Y, then Z, and then X
C. Z, then X, and then Y
D. Z, then Y, and then X

Seventy-two percent of eighth-graders could not apply the principles of combustion and oxygen depletion to solve this problem.


EXAMPLE 2. SCIENCE—LEVEL 350
Northern U.S.
Southwest U.S.
Northern Europe
If the diagrams above represent rock layers at three different places on Earth and the shapes in the diagrams represent the types of fossils found in each rock layer, which of the following is most likely to be found immediately below the lowest rock layer in the Southwest U.S.?
A.
B.
C.
D.

Judging from their answers to this problem, which calls for integrating data in the diagrams with geological knowledge, 91 percent of seniors are unprepared for college work in science.

by high school few students find science classes "fun," according to research that was carried out by the NAEP in a 20-year-long study. The National Research Council has estimated that 75 percent of the nation's high school graduates are so ill-equipped that they would flunk out of a college-level math or engineering course.

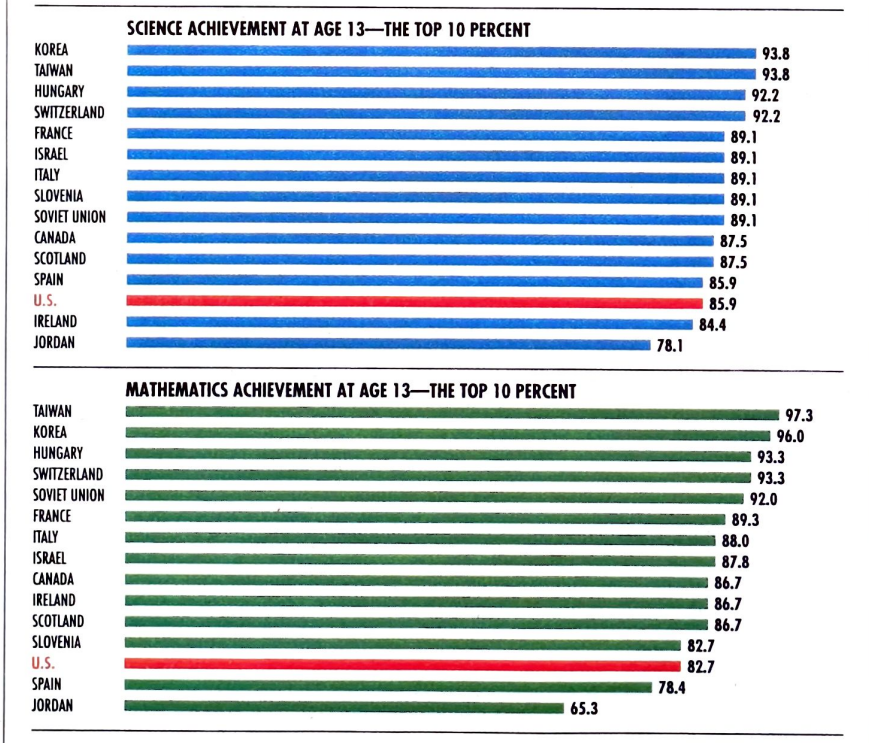
That is a recipe for national disaster.

"By the year 2000," explains Luther S. Williams, long-time assistant director for education and human resources at the National Science Foundation, "the number of college-age students will have declined to a level somewhat below the level in 1970. What this means is that unless a greater proportion of the student population is attracted to the sciences and engineering, America's once-impressive lead in science and engineering personnel may erode. Japan, for example, has doubled its technical work force in the last two decades and trains almost as many engineers as we do with half the population."

The achievement gap for black and Hispanic minorities poses a particularly acute problem. By the year 2000, minority students will account for 40 percent of the U.S. elementary and high school population, up from about 30 percent in 1990. As the work force expands, it will be increasingly minority and female; but these groups are drastically underrepresented in working scientists, mathematicians, and engineers. In 1990, only 8 percent of the bachelor's degrees in science and engineering—and only 4 percent of the doctorates—were awarded to blacks and Hispanics. Women earned about 40 percent of the bachelor's degrees in these fields, but only about 25 percent of the doctorates.

"We allow, and in the case of girls and minority boys, even encourage, students to drop out of mathematics classes before high school graduation," says Betty Vetter, executive director of the Commission on Professionals in Science and Technology.

HOW U.S. STUDENTS COMPARE INTERNATIONALLY

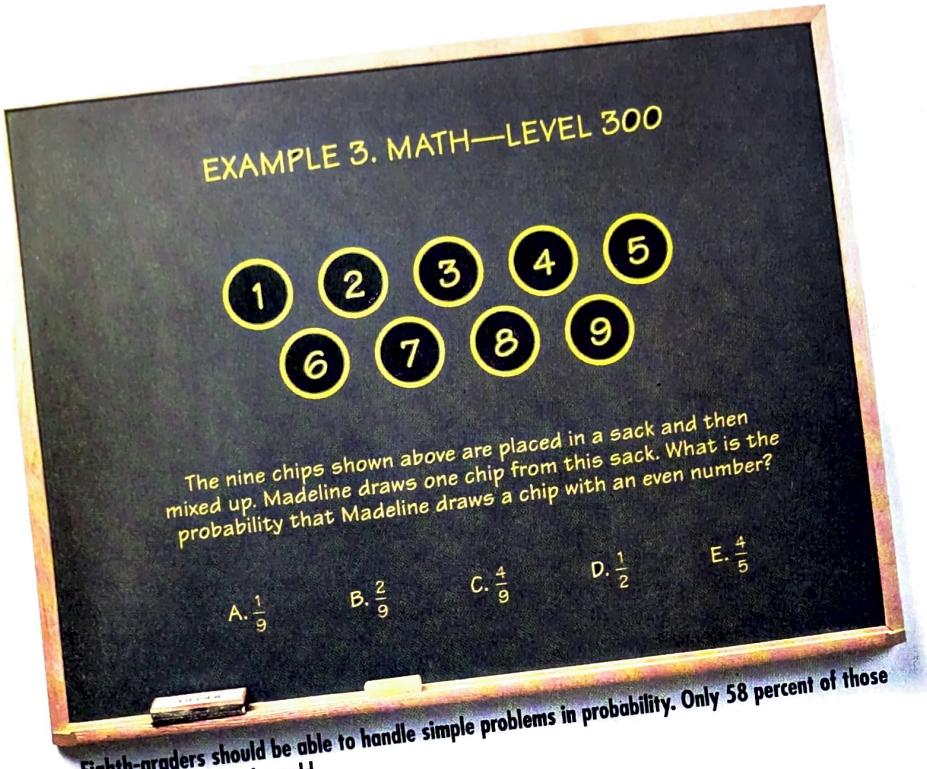


Percentage of science and math questions answered correctly by "top" students from 15 countries. The United States ranked near the bottom in both.

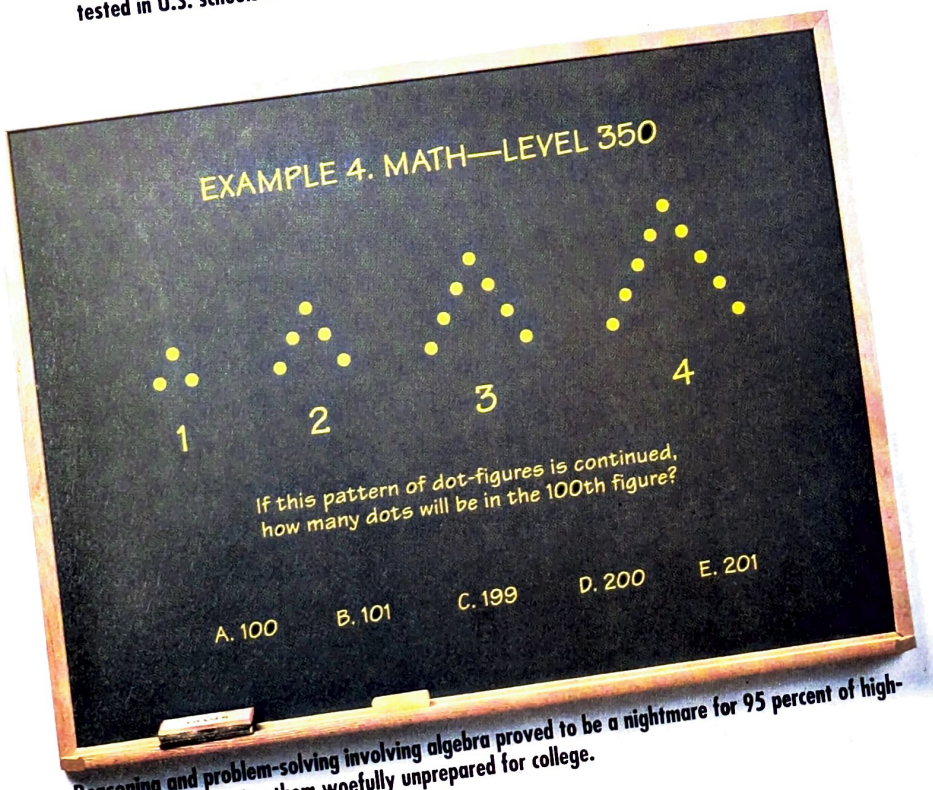
The consequences of this education gap in science and math are devastatingly apparent. Only 45 percent of adult Americans know that Earth goes around the sun once each year. A third believe that boiling radioactive milk makes it safe to drink. Some 40 percent firmly believe that aliens from space have visited Earth, and a stunning 54 percent reject the idea that humans evolved from earlier species.

Jon D. Miller at Northern Illinois University surveyed 2,000 adults, representing an educational cross section, and asked them such true or false questions as "The earliest human beings lived at the same time as the dinosaurs" and "Antibiotics kill viruses as well as bacteria." Only 37 percent answered the first question correctly, only 26 percent the second. On the basis of several such surveys, Miller concludes that no more than an astonishing 6 percent of the American population is scientifically literate, and that only some 17 percent of American college graduates and 25 percent of those with advanced degrees have even a basic grasp of science.

In one notorious incident, 23 Harvard University seniors were asked by


EXAMPLE 3. MATH—LEVEL 300
1 2 3 4 5 6 7 8 9
The nine chips shown above are placed in a sack and then mixed up. Madeline draws one chip from this sack. What is the probability that Madeline draws a chip with an even number?
A. 1/9 B. 2/9 C. 4/9 D. 1/2 E. 4/5

Eighth-graders should be able to handle simple problems in probability. Only 58 percent of those tested in U.S. schools could.


EXAMPLE 4. MATH—LEVEL 350
1 2 3 4
If this pattern of dot-figures is continued, how many dots will be in the 100th figure?
A. 100 B. 101 C. 199 D. 200 E. 201

Reasoning and problem-solving involving algebra proved to be a nightmare for 95 percent of high-school seniors, leaving them woefully unprepared for college.

a filmmaker—while they were still wearing their graduation robes—why it is hotter in summer than in winter. Only two students could answer correctly.

One result of the educational time bomb is a shrinking number of Americans who are seeking advanced degrees in either scientific or mathematical disciplines. In 1989, 861 doctorates in mathematics were granted in the United States; only 45 percent went to American students. Also that year, 15,478 doctorates were awarded in science and engineering; only 60 percent went to Americans. The number of doctorates in all subjects received by Americans in 1970 was almost 25,000; in 1989 the total had dropped to 23,172. Yet the numbers for foreign students over the same interval showed an increase from 4,148 to 8,195.

One reason for the swelling ranks of foreign students in graduate programs of science and engineering is that the United States provides superbly equipped research laboratories at the graduate level. Combine that with the growing dropout factor among American students, and the result is something close to foreign dominance at many institutions. At the University of Texas at Austin, for example, the civil engineering department in 1990 had about 350 graduate students; some 200 of them came from other countries.

The overall situation is extremely worrisome to leaders in science and math, education, and business. A recent Union Carbide report on education was titled "Undereducated, Uncompetitive U.S.A." Norman Augustine, chairman and chief executive officer of Martin Marietta Corp., has written that "the shortcomings help explain why one major U.S. employer got an 84 percent failure rate after testing 23,000 applicants for entry-level positions or why another routinely rejects up to 90 percent of its entry-level applicants because they cannot meet a ninth-grade math skills requirement. Productivity losses caused by poorly trained workers and remedial training cost American industry more than $25 billion a year—a cost that America's toughest foreign competitors do not have."

The so-called pipeline of science and engineering, with children poured by the hundreds of thousands into one end at ages three to five, resembles something like an eyedropper at the other end. According to National Science Foundation figures, only about 15 percent of college freshmen plan to major in science or engineering. Of the four million American high school sophomores in 1977, only a trickle—9,700—will earn a doctorate in the natural sciences or engineering in 1992.

The reader of such statistics might almost wonder if our present educational system were actually designed to discourage an interest in these fields. Douglas Lapp, director of the National Science Resources Center, says that "at the elementary school level, in many school districts, the teaching of science has virtually disappeared from the curriculum. Often the little science that [remains] is taught in a way that discourages children from taking additional science courses when they go to secondary school."

According to the 1991 "Science and Engineering Indicators" published by the National Science Board, nearly 30 percent of all seventh-graders express a preference for a career in science or engineering. But this percentage declines steadily through middle and high school, so that by twelfth grade,

[*Continued on page 108*]

While every 4x4 devotee knows the road to heaven isn't paved at all, the road *to* the road to heaven assuredly is. Thus the wisdom of the new Yukon. A full-size sport utility that is not only obliging of your desire to bully the Continental Divide, but nimble on

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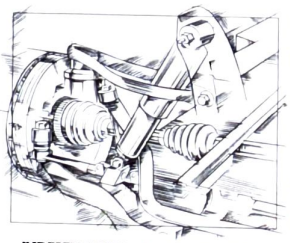

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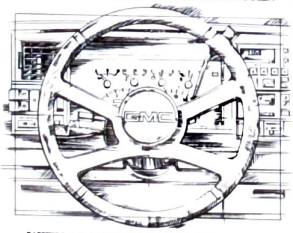

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POPULAR SCIENCE debuted at the beginning of a growing ferment, the unfolding of a uniquely American era of science and technology, peopled by wizards like Bell, Edison, Tesla, Marconi, and Westinghouse.

What a torrent of inventions and scientific discoveries the past 120 years have seen! And how many different "ages" humanity has lived through in only four generations—the electric age, the nuclear age, the TV age, the space age, the information age.

Many of these transformations have had a profound impact on the world and its peoples. The telephone, radio, and television have made virtually instant communication possible between people anywhere on Earth. The automobile, high-speed train, jet, and supersonic aircraft have shrunk physical distances by amounts unimaginable in 1872. The triumphant unraveling of the genetic code is already helping to overcome disease and to increase the world's food supply. The penetration of the atom and of the heavens by powerful new tools is helping to assemble, bit by bit, a mosaic of the ultimate nature of the universe. The discovery of nuclear fission and fusion have both brightened and shadowed the prospects for civilization.

This 32-page special section highlights the scientific and technological achievements of the past 120 years, as they appeared in the pages of POPULAR SCIENCE. (Also included is a sampling of magazine advertisements from the past.)

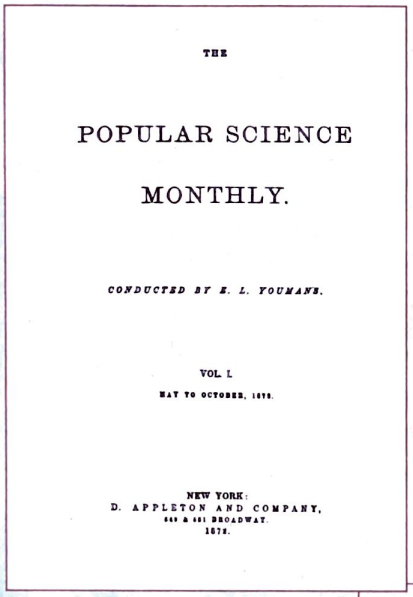
Welcome, then, to a retrospective look at this incredible era.

EDITED BY SUZANNE KANTRA AND JUDITH ANNE YEAPLE

1870s

Volume 1, Number 1

"To interest the nonscientific public and to create a taste for scientific literature, and an appreciation of scientific knowledge," wrote Edward Livingston Youmans (1821-1887) when he founded Popular Science Monthly. The first issue's printing of 5,000 copies quickly sold out; in less than two years, circulation had reached 12,000. —May 1872


THE

POPULAR SCIENCE

MONTHLY.

CONDUCTED BY E. L. YOUMANS.

VOL. I.

MAY TO OCTOBER, 1872.

NEW YORK:
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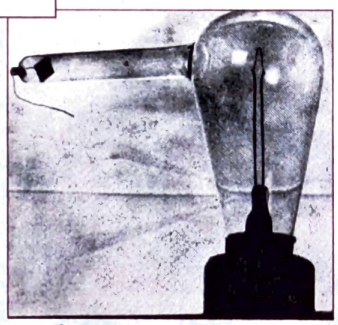
549 & 551 BROADWAY.
1872.

Hello?

Alexander Graham Bell's telephone first had to prove itself as a viable alternative to the accepted communication medium of the day, the telegraph. "The telephone has been regarded as a toy, or a curiosity to be played with, but while it is undoubtedly extremely interesting as a novelty, it is very much more than this; it is, scientifically and practically, a great success." —March 1878

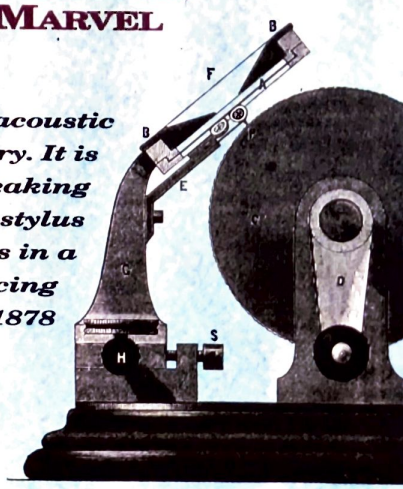
Electric Light vs. Gas Light

Edison's electric lamp "gave out a very pleasant, moderate light. These lamps, it is said, can be made very cheaply." But the editors of Popular Science were not convinced: "The use of gas in dwellings is so convenient and safe that for many years it will constitute the chief means of artificial illumination." —February 1880


BETTMANN

Acoustic Marvel

"Mr. Thomas A. Edison has recently invented an instrument which is undoubtedly the acoustic marvel of the century. It is called the 'Speaking Phonograph.'" A steel stylus "reads" indentations in a thin foil tube, reproducing sound.—April 1878



Tech Notes

Whither the Weather?

"All storms owe their origin to the heat of the sun, which produces differences of temperature in different portions of the Earth." The theory: Temperature differential creates two sets of currents—tropical and polar—that merge in temperate zones. This new weather-pattern theory helped resolve questions on barometric changes, cloud patterns, and storm fronts.
•July 1876

Save the Buffalo

During just a single hunting season, at least 250,000 buffalo were slain near the Atchison, Topeka & Santa Fe Railroad line; only the animals' hides were used. "At this rate, the bison will have utterly disappeared before many years, unless government interferes to prevent this wasteful slaughter."
•July 1876

Running Out of Trees by 1890

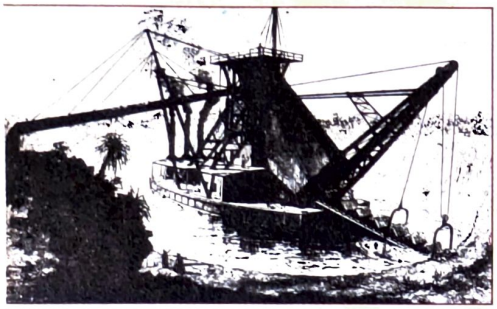
"The impression prevails that when our supply of lumber fails, as it must inevitably within the next ten years, we can find an inexhaustible supply in Canada. But this is an error . . . there is not, from Manitoba to the Gulf of St. Lawrence, as much commercial timber as would supply the United States for even three years!"
•February 1879

First telephone exchange ... Thomas Edison invents phonograph and electric light ...

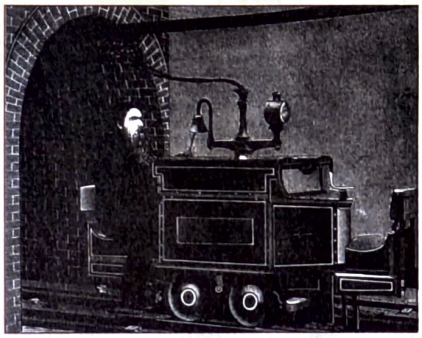
1880s

Panama Canal Begun

Steam-powered dredges like the American-built City of New York were regarded as essential in the first attempts to dig a canal across Panama's isthmus. Financial and engineering problems plagued construction, however; the canal was not completed until 1914.
—December 1887



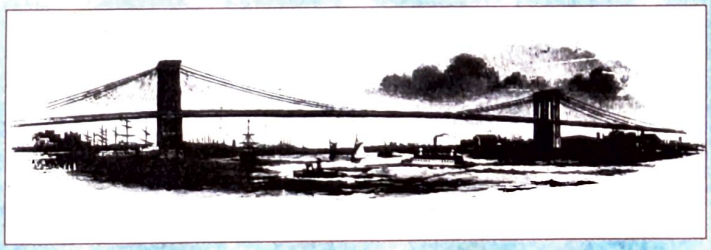
Clean and Quiet Railways



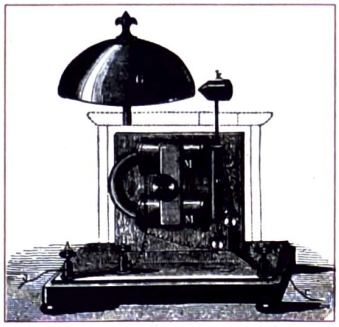
New electric railroads might someday lead to city-to-city travel in 60-mph trains with heated compartments and "mild and steady" incandescent lights—but no smoke or cinders. They were being developed by Thomas Edison in the United States and by Werner Siemens in Europe (pictured).—April 1884

World's Biggest Bridge

When it opened on May 24, 1883, New York City's East River Bridge broke engineering records with its central span of 1,595 feet. Later known as the Brooklyn Bridge, the $16,000,000 structure was so impressive at the time that Popular Science exclaimed, "What hath man wrought!"—July 1883



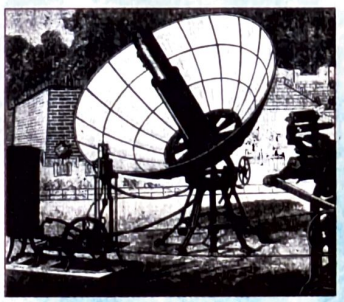
BETTMANN



Early Alarms

New electric alarm systems used a magnet, spring, and clapper arrangement to warn of an intruder, who would set off the alarm by touching concealed pins in metallic sleeves, thus breaking the circuit.
—November 1880

Sun-Powered Printing Press



French inventor Abel Pifre devised a 12-foot-diameter reflector that abandoned the usual conical shape for a parabolic one. The solar collector generated steam to drive a small printing press in Paris.—July 1883

TECH NOTES

Preparing for Lady Liberty

With the Statue of Liberty on its way from France, a suitable pedestal was needed in New York Harbor. The editors of Popular Science urged the public to raise the necessary $200,000.•December 1882

Time and Time Again

More than 50 local time zones across the United States created a scheduling nightmare for the railroads. "Standard" time, which divided the country into five time zones, ended the confusion.•December 1884

Killer Gas

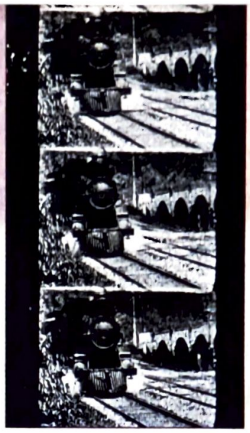
The lack of standards in plumbing made "sewer gas" a deadly threat in any home with running water. Popular Science urged that U-shaped water seals be incorporated in all fixtures to block gases from entering houses.•July 1888

Camera Ready

With the introduction of George Eastman's first Kodak camera, photography became accessible to the average person—and valuable to scientists. "It is an absolutely unprejudiced observer. The value of photography in geographical science is now so well admitted that an explorer would almost as soon think of starting without a rifle as without a camera."
•November 1888

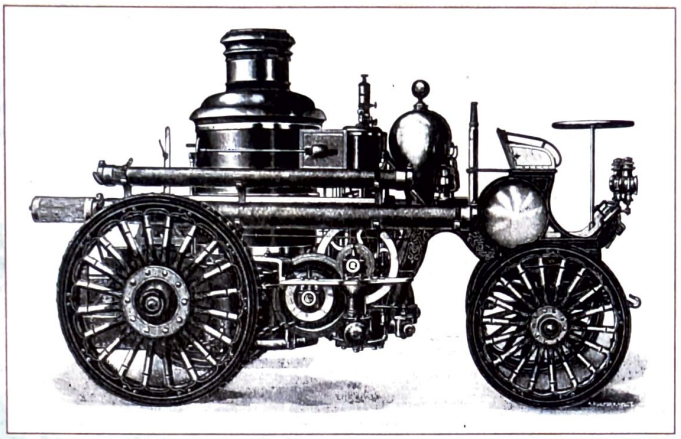
Custer's Last Stand ... Johnstown flood kills 2,200 ... Brooklyn Bridge completed ...

1890s



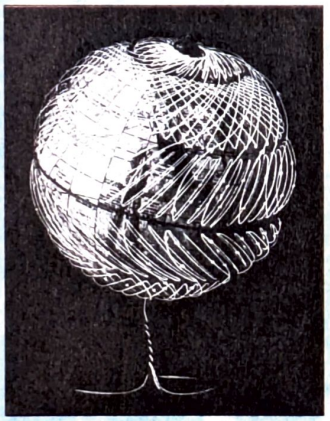
Moving Pictures

The movies became popular only after the invention of the cinematograph, a device that reduced the jerkiness of subjects' movements produced by Edison's kinetoscope. "As a means of permanently recording and vividly illustrating notable events, its importance will scarcely be overestimated."
—December 1897



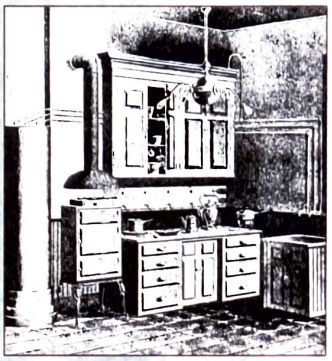
Get a Horse!

Self-propelled fire engines were not popular at first. "Boston, New York, Detroit, and Chicago have all tried them, but they have been discarded for engines drawn by horses." Hartford's self-propelled engine, nicknamed *Jumbo*, was an exception.—August 1895



Predicting the Weather

"Weather forecasting is a matter of so much concern that our government spends annually about $900,000 in order that we may know a few hours beforehand what to expect of the elements."
—July 1898



Current Cooking

The electric kitchen displayed at the World's Columbian Exposition in Chicago included hot plates, broilers, and hot-water heaters. The burners resembled those used in kitchens today—a coil of wire embedded in ceramic compound.—October 1893

X-Ray Vision

The first X-rays required that the object be exposed for well over a minute. Although the human hand posed little problem in 1896, attempts to view the brain and thicker portions of the body remained unsuccessful.—April 1896

Tech Notes

Pasteurized Milk

Milk was being pasteurized in Europe, but it was still not available in the United States. "Experience with its superior keeping properties would soon create a demand for it in America as it has already done in the larger cities of France and Germany." •April 1892

The Trolley Age

With the railroad industry nervously watching, trolleys "practically captured the cheap transportation field" and even a transcontinental trolley was predicted. "It looks as if the next century, whatever it may have in the way of aerial flight in store for us, will have no difficulty of being christened 'the trolley age.' "•April 1895

Liquid Hydrogen

Hydrogen was the last of the "permanent gases" to be liquefied. "With liquid hydrogen as the cooling agent a temperature could be reached within 20 to 30 degrees of the zero of absolute temperature, and its use would open up an entirely new field of scientific inquiry."•September 1898

Wireless

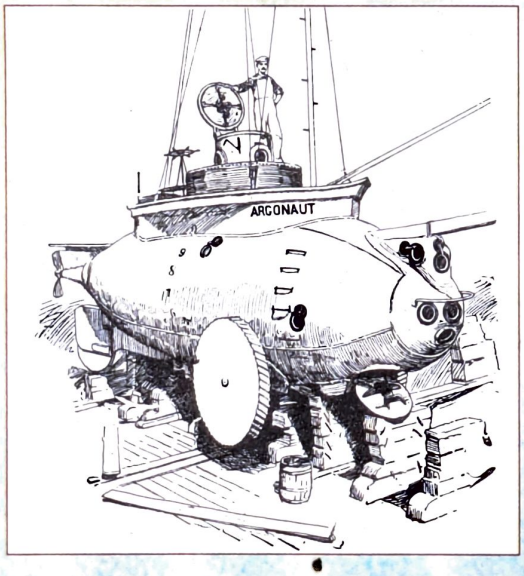
By enabling messages to be sent with radio signals across wide distances, Guglielmo Marconi's wireless telegraph revolutionized communications. •November 1899

The first movies ... Einstein's Theory of Relativity ... Marconi invents wireless ...

1900s

Steam, Electric, or Gasoline?

At the first National Automobile Show, held in New York City in 1900, skeptical visitors tested their ability to maneuver through an obstacle course. Early cars were powered by steam, electricity, and gasoline—all considered viable options. Steam vehicles could run anywhere, but "exhaust steam is visible in cold or wet weather." Electric cars were "noiseless, odorless, and free from smoke," but could "only be used where batteries can be recharged." While gasoline vehicles ran well, they were "noisy and the odor of gasoline is disagreeable as well."—August, September, October 1900

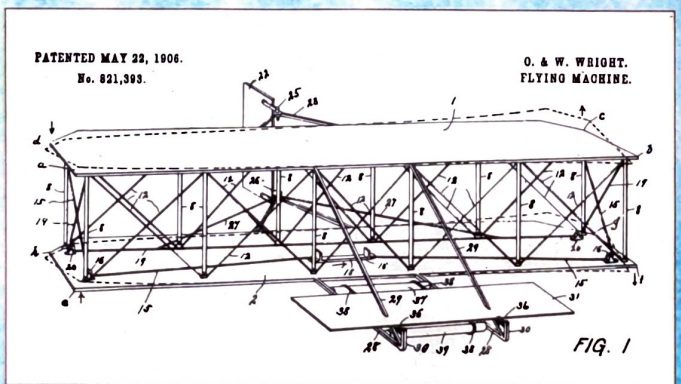


Exploring the Ocean

The first submarine to roam the open ocean, the three-wheeled *Argonaut* was built for commercial, not military, service. The *Argonaut* didn't store air for its crew; instead, intake and exhaust pipes connected the craft with the surface. Divers slipped in and out through an open "sea door."—December 1900

First Flight

"A successful dynamic flying machine seems to have been produced by the Messrs. Wright. Too much praise cannot be awarded to these gentlemen."
—March 1904



Tech Notes

Metric Resistance

Despite repeated attempts to replace the British system of weights and measures with the decimal-based metric system, it never happened. A succession of bills before Congress to require the adoption of the metric system failed. Popular Science concluded that those who favor the metric system "will need to be patient."•March 1904

Going Underground

The growth of the telephone led to a jungle of overhead wires. Engineers devised a way to bury the lines, and soon more than one-half of all cables were installed underground. •July 1907

Orthodontics Take Shape

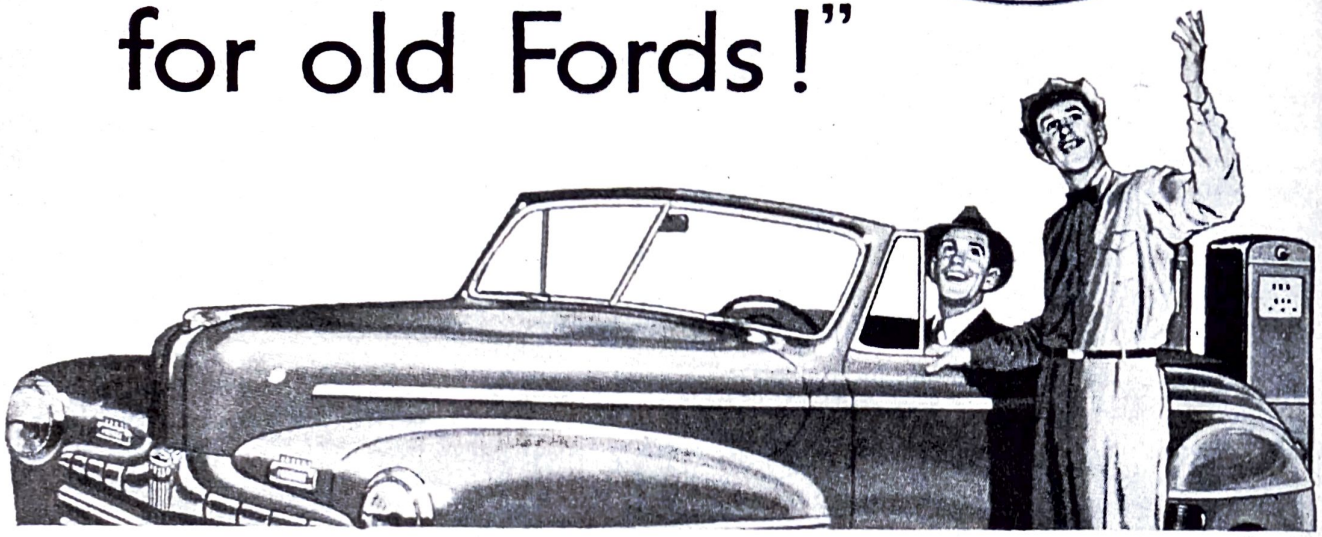
"A Revolution in Dentistry" heralded the advent of orthodontia, which was practiced by 60 of the 50,000 dentists in America. "A simple arrangement of springs and wires need hardly annoy the child." •July 1909

Sport or Science?

"Reaching the North Pole and flying across the British Channel are sporting events of the first magnitude," remarked the editors. While neither event may be "a serious contribution to science, these achievements exhibit the conquest of nature by man."•October 1909

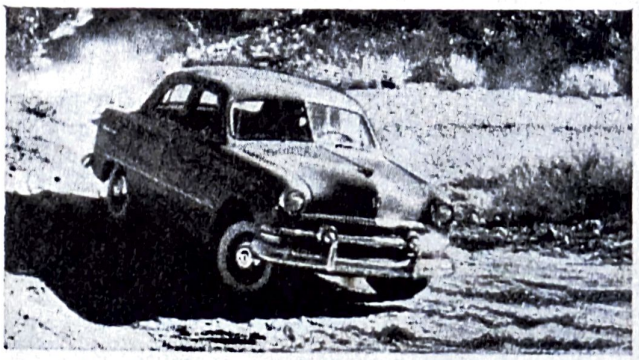
First transcontinental automobile trip ... Wright Brothers fly at Kitty Hawk, N.C. ..

"They're a new lease on life for old Fords!"



Genuine Ford Parts are just naturally the best parts you can put into your Ford. Here's why:

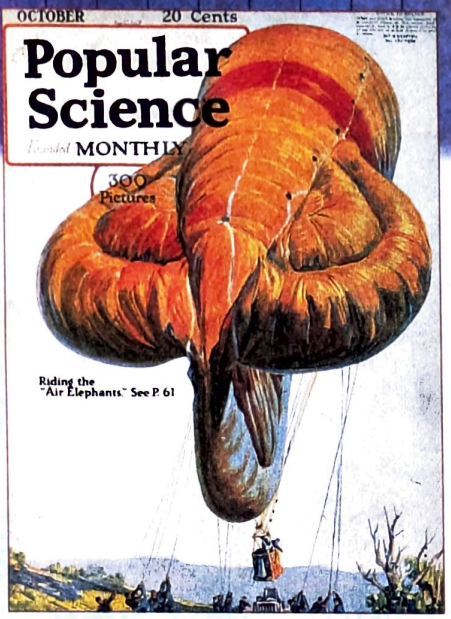
They're made right to fit right by the men who made your Ford . . . often on the same production lines as the parts now in your Ford. That's why they're easy to install, and that's one reason they save your time, your money, and your Ford. In addition . . .



They're Track Tested and proved by Ford engineers who give them the toughest imagin—able tests. When they meet Ford's high standards, they become Genuine Ford Parts and you can be sure they're built to last and *last!*

They're easy to get!
They're available at all Ford Dealers and the selected independent garages where you see this sign.

Insist on the parts that keep your Ford All Ford



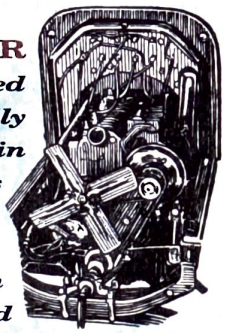
1910s

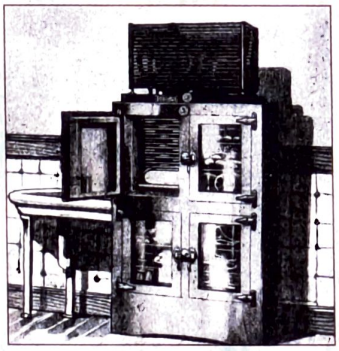
When Elephants Fly

Hovering high in the air and equipped with telephone communications equipment, observation balloons permitted the tracking of enemy movements on the ground. The balloon pictured on the cover earned the name "air elephant" from a fin that steered the craft and made it more maneuverable.—October 1918

Self-Starter

Charles Kettering invented the first commercially successful electric starter in 1912. A starter/generator was also developed for Ford's Model T. In addition to starting the engine, the system powered the "head, side, and tail lights."—July 1915





Electric Dishwasher

"Soapy water is forced into the tank by a pump and is spread over the dishes through nozzles. After the first operation, hot water is forced over the dishes, after which the dishes dry from the heat."—November 1915

Cold Storage

"There is no sound scientific reason why a household refrigerating machine should not be a success." Early refrigerators used sulfur dioxide as a refrigerant but, at $900, were considered too expensive for general use.—June 1916

Halley's Comet Arrives on Schedule

The sighting of Halley's comet on May 4, 1910, marked the first correctly calculated prediction of a comet's passing. Edmond Halley had even properly attributed the deviations in the comet's 75-year trajectory to the gravitational pull of Jupiter and Saturn.—January 1910

Tech Notes

South Pole Reached

Capt. Roald Admunsen reached the South Pole on Dec. 14, 1911. "The great ice plane without a trace of life appeals to the imagination, but traversing the plane has probably not added considerably to our scientific knowledge, and there does not seem to be much likelihood of economic gains." •January 1912

Garage Door Opener

An "electrical long-distance door controller" opened garage doors by the simple turn of a key. Mounted on a post outside of the garage, the device opened, closed, and locked the door. •November 1915

Electric Car

An electric delivery wagon proposed by inventor Thomas Edison weighed 750 pounds, including battery, and could run 35 miles before recharging, which could "be done at a public station at smaller cost than the shoeing of a horse." •November 1915

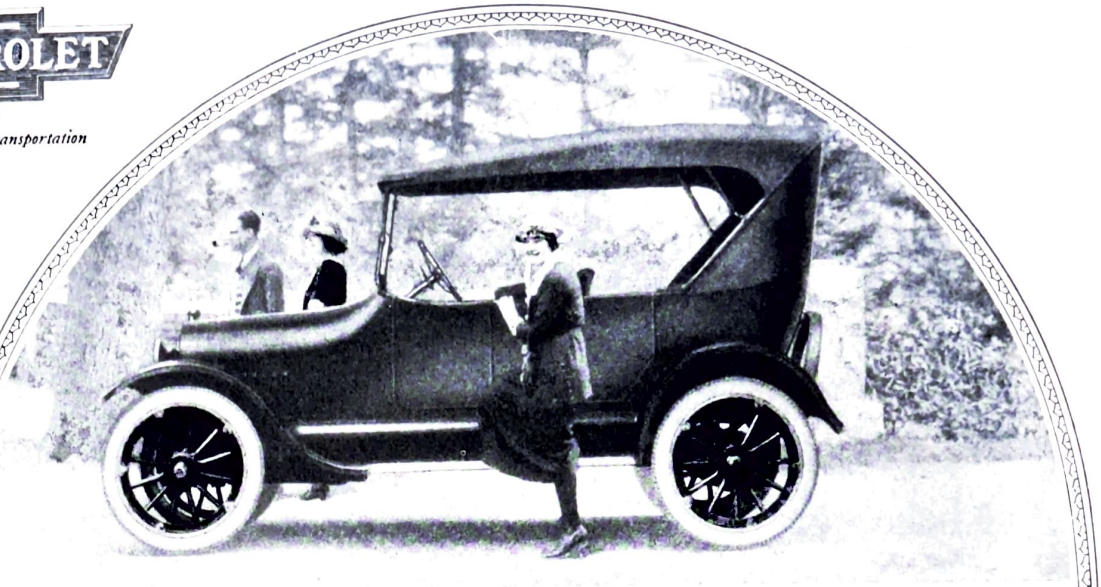
Daylight Savings

"The project of advancing the clock in summer in order to persuade slothful humanity to keep early hours at that season, after nearly a decade of unsuccess in getting itself taken seriously, has suddenly come to fruition under the stress of war conditions."•April 1918

First flight across the United States ... World War I ... Russian Revolution ...

CHEVROLET

for
Economical Transportation



WHY CHEVROLET IS BECOMING THE MOST POPULAR AUTOMOBILE IN AMERICA

Public favor changes when reasons for a change are obvious. Public opinion as to the most popular car of the future *is* changing.

Users of low-priced motor transportation are demanding completely equipped automobiles, modern in every respect, with nothing left to buy but the license plate. The New Superior Chevrolet is FULLY EQUIPPED, including modern 3 speed and reverse sliding gear transmission, standard service and hand brakes, electric starter, demountable rims, water and oil pumps, and speedometer.

In addition to completeness, buyers insist on real economy in four important essentials. They demand *low gasoline consumption; low oil consumption; low repair costs; long tire life.* The New Superior Chevrolet excels in these particulars.

Twenty-five miles on each gallon of gasoline is not uncommon for a New Superior Chevrolet. It excels in oil economy as well. Repair costs are low because every Chevrolet part is built to give long life under hard conditions.

These are a few of the reasons why public favor is increasing toward the Chevrolet—why it is becoming the favorite low-priced car of America. Chevrolet distribution is practically universal. Cars can be bought from over five thousand dealers located in almost every American community, and abroad, and their number is daily increasing.

You owe it to yourself to examine the New Superior Chevrolet, the car which is establishing new standards in the medium and low price field.

CHEVROLET MOTOR COMPANY

Division of General Motors Corporation
DETROIT, MICHIGAN

5000 Dealers and Service Stations throughout the World.
Consideration will be given to applications from HIGH-GRADE dealers in territory not adequately covered.

Superior Roadster, $525 — *Superior Touring, (Illustrated above) $525* — *Superior Sedan, $875* — *Superior Coupé, $875*
Model FB 12 Roadster, $975 — *Model FB 32 Touring, $975* — *Model FB 42 Sedan, $1575* — *Model FB 22 Coupé, $1575*
Light Delivery Wagon ½ Ton Complete, $525 — *Model "G" Truck ¾ Ton Chassis, $745* — *Model "T" Truck 1 Ton Chassis, $1125*

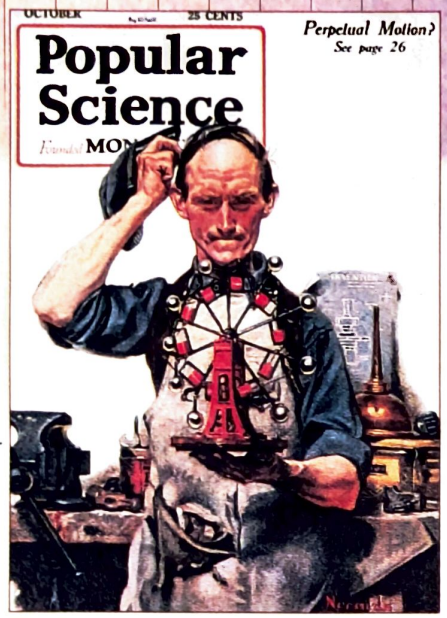
F. O. B. Flint, Michigan. (Prices subject to change without notice.)

CHEVROLET

FOR ECONOMICAL TRANSPORTATION

1923

1920s

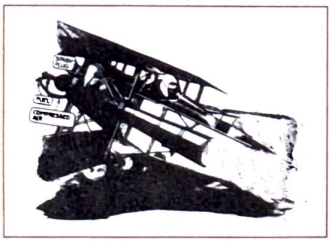


Perpetual Hoax

With his trademark gentle humor, Norman Rockwell illustrated this cover story, which investigated perpetual motion machines. The article was more blunt, stating that the best use for perpetual motion devices "lies in the mental exercise required for pointing out their fallacies."—October 1920

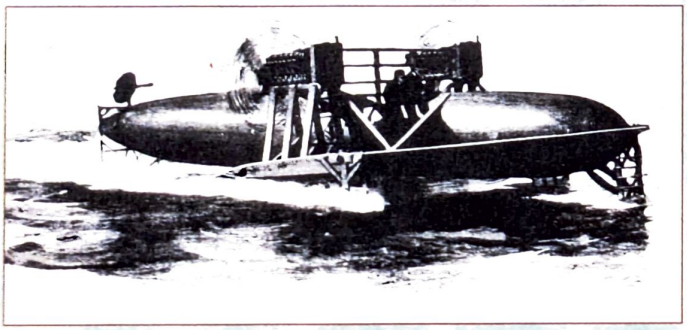
Lucky Lindy

When Lindbergh left for Paris on the morning of May 20, 1927, he was almost unknown; the next day he was a world hero. The young pilot "has done more than any other to arouse interest in aviation."—July 1929



Jet-Setter

The "most radical" exhibit at the Aeronautical Show in Paris was a propulsion engine developed by F. Melot. His scheme: an air-and-fuel mixture under high pressure that, when fired by a spark plug, would produce a blast that "kicked" against the air.—December 1920



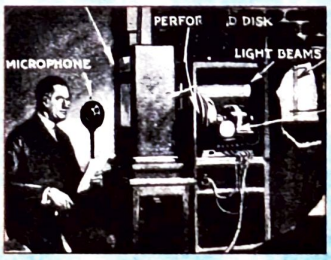
Boat Plane

Alexander Graham Bell's experimental watercraft, the HD-4, was the "first really successful embodiment" of the hydrofoil principle. Three submerged plates planed on the water, pushing the hull above the waves.—March 1920

You-Dial-It

"Every home in America is going to be its own exchange." To place a call, the user turned the dial with his finger. If the line was clear, he heard the number ring. If not, he heard a "busy" signal.—November 1921

TV Preview



"Before long, we shall see distant men and events by radio as we sit in our homes, as clearly as we now listen to faraway voices and music," predicted the editors after the first images were transmitted from Whippany, N.J., to New York City.—June 1927

Tech Notes

Moon Rocket

Professor Goddard's rocket design "transfers the enterprise of hurling a missile to the moon from the class of impractical dreams to the domain of comparably simple tasks." By tapering the exhaust nozzle, Goddard's design boosted the rocket's thrust, and thereby reduced the amount of fuel needed. •April 1920

Radio Days

Thanks to simple, inexpensive receiving sets, nearly a half million Americans began tuning in to radio broadcasts. Fans stepped up to more complex equipment, including "tuning" devices and vacuum-tube detectors. •November 1921

London Calling

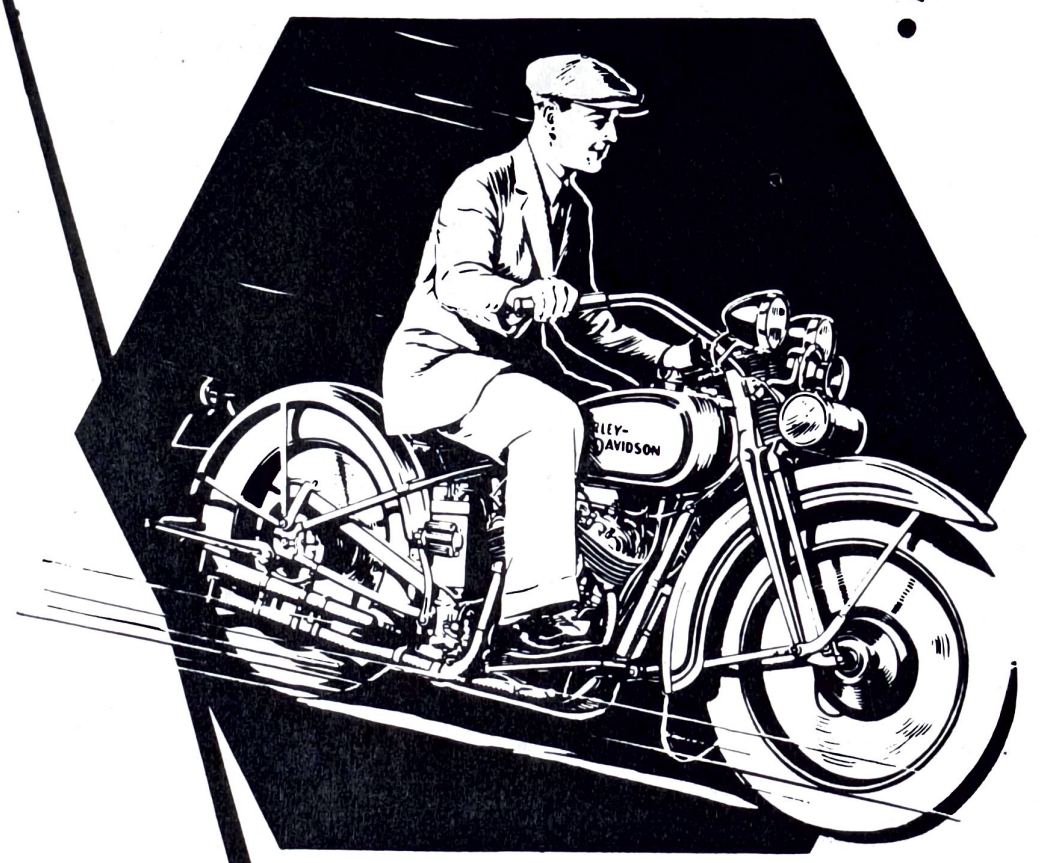
"Within a few months, calling up London or the Continent from any part of this country will be no more remarkable than calling New York from Chicago." High-powered radio stations at New York and Rugby, England, bridged the gap between the wire-based systems. •July 1925

The Cloverleaf

A new highway intersection could safely handle more cars traveling at high speeds. One highway crossed over the other via a bridge; drivers used circular on/off ramps to leave one road and merge onto the other. •August 1925

First motion picture with sound ... Lindbergh flies from New York to Paris ...

WHOOPEE on Wheels!



WHOOPEE that's healthful — motorcycling, sport of a thousand thrills!

Whirling wheels on a winding road—motor that purrs when it's working hard, and whispers at racing speed!

Ride away on a "45" Twin, 1930 model, and revel in motorcycling at its best. On long tour or short ride, you'll enjoy every mile — and the miles will cost you almost nothing.

Your dealer wants to show you the 1930 models. See him today—ask about his Pay-As-You-Ride Plan.

6 Important Improvements for 1930

HARLEY-DAVIDSON

Motorcycles

1930

AIR FORCE JOBS

And How They Lead to
CAREER OPPORTUNITIES
In the Air Force and in Civilian Life

Airmen are select men—selected for intelligence, and high moral and physical qualifications.

Airmen are select men in another way too—selected for Air Force careers on the basis of individual aptitudes.

Most Air Force jobs have counterparts in civilian life. Your training in the Air Force—with pay and all advantages—fits you for responsible jobs in the Air Force or in civilian life as well.

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U. S. AIR FORCE

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AIR FORCE CAREER FIELDS
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- ARMAMENT SYSTEMS
- FOOD SERVICE
- TRAINING DEVICES MAINTENANCE
- AIR TRAFFIC CONTROL AND WARNING
- WIRE MAINTENANCE
- MISSILE GUIDANCE SYSTEMS
- COMMUNICATIONS
- OPERATIONS
- PHOTOMAPPING

1950

"They sure don't make 'em the way they used to!"

Look at the 1914 job on the left. 4 cylinders, 25 horsepower, chain drive. Carried a 2-ton payload at 12 miles per-hour. On wood spoke wheels with solid rubber tires. Oil lamps for after dark. Quite a rig in its day!

That's a 1965 model on the right. A lightweight, diesel-powered beauty. Hauls over 25 tons of the good things America depends upon. Maintains highway speeds with ease.

Trucks have come a long way in 50 years. And they've brought better living right along with them. Better living will continue to come by truck.

GMC
GENERAL MOTORS CORPORATION
TRUCKS
FROM ¼ TO 50 TONS

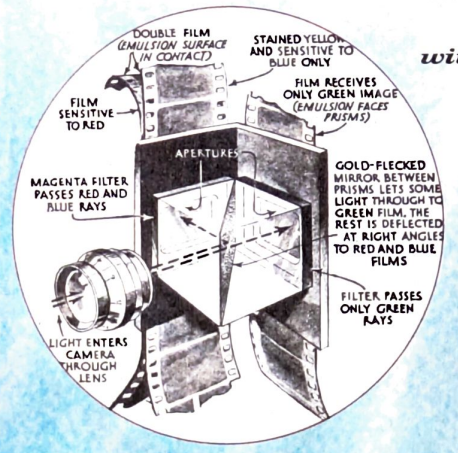
MEMBER

ATA FOUNDATION INC
American Trucking Industry

1930s

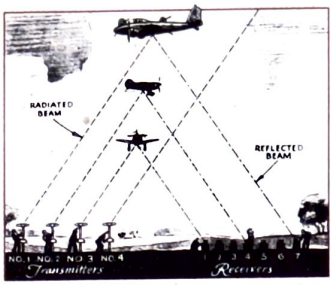
Lights, Action, Color!

Just five years after *The Jazz Singer* ushered in the talkies, new color cameras were used to make *Becky Sharp*, the first color movie. Not only were the actors in colorful costumes, but the lights were fitted with color filters to create a variety of moods. —May 1935


DOUBLE FILM (EMULSION SURFACE IN CONTACT)
STAINED YELLOW AND SENSITIVE TO BLUE ONLY
FILM RECEIVES ONLY GREEN IMAGE (EMULSION FACES PRISMS)
FILM SENSITIVE TO RED
APERTURES
MAGENTA FILTER PASSES RED AND BLUE RAYS
GOLD-FLECKED MIRROR BETWEEN PRISMS LETS SOME LIGHT THROUGH TO GREEN FILM. THE REST IS DEFLECTED AT RIGHT ANGLES TO RED AND BLUE FILMS
FILTER PASSES ONLY GREEN RAYS
LIGHT ENTERS CAMERA THROUGH LENS

The Once and Future Commuter

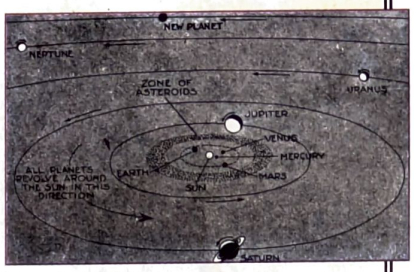
A British prototype monorail featured cars that were electrically driven by two propellers—one in front, the other in back. "The streamlined cars may soon whiz at 150 mph, offering a new system of travel for interurban commuters."—October 1930



Spotting the Enemy

"U.S. Army experimenters are trying out a secret new weapon for use against possible invaders—a 'mystery ray' device reputedly capable of locating an enemy vessel as far as 50 miles at sea." The "mystery ray" was radar, which was also being developed in Germany.—October 1935

Pluto, the Planet



"It behaves differently from other planets. Its orbit is so far from a perfect circle, and tilted so askew, that astronomers hesitate to declare it a planet with certainty." "It" was Pluto, the ninth planet in our solar system.—June 1930

Tech Notes

FM Radio

"A static-free system of radio transmission that turns accepted principles topsy-turvy has just been announced by Maj. Edwin H. Armstrong, one of America's leading radio engineers."•July 1935

Around the World in 20 Days

"Before the end of this summer, you will be able to buy tickets for an aerial circuit of the earth as easily as you now purchase them for a round-the-world cruise by steamer." The journey included legs on Pan Am's *China Clipper* and the zeppelin *Von Hindenburg*. The price of the 25,292-mile trip: $2,465. •June 1936

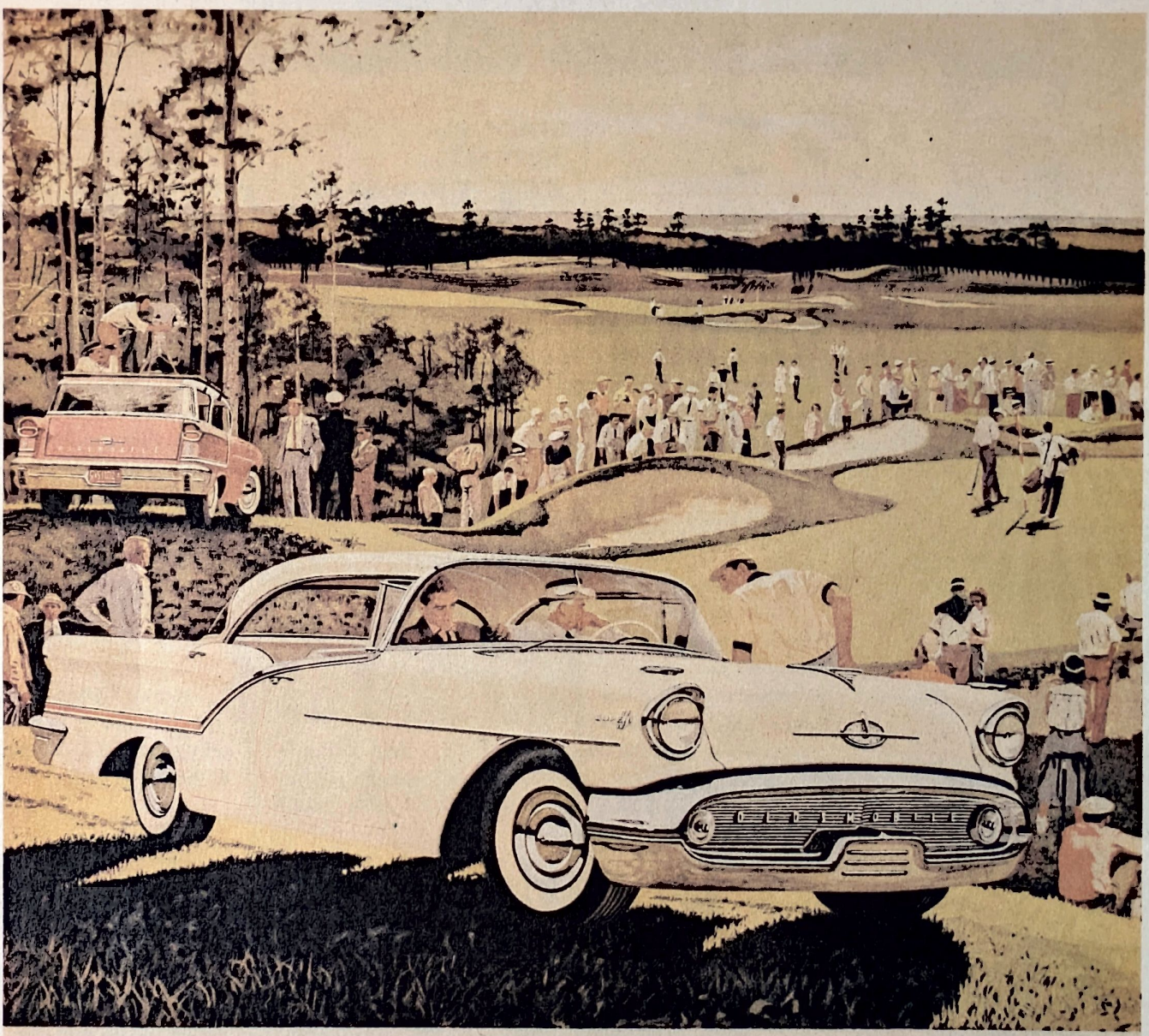
Flattering Fluorescents

Early fluorescents had been used in street lamps, but the lamps were shunned for interior use because of the unflattering light they cast. Improvements in light quality allowed fluorescents to be used indoors.•June 1936

Out With the Old . . .

"Synthetic materials are surpassing nature's counterpart: A new synthetic fiber for clothing is one-third thinner than once incomparable silk; glass airplane windows are being replaced with more flexible panes of plastic."•July 1936

The Great Depression ... Roosevelt's New Deal ... Empire State Building opens ...



SUPER 88 HOLIDAY SEDAN

Check the Score... AND YOU'LL GO OVER TO OLDS!

SUPER 88

You're in for a whole series of pleasant surprises when you first check the score on Olds ownership.

Very likely, you'll find the price less than you imagined—most people do! And when it comes to value, it's great to see how much more Oldsmobile offers for your every dollar. *Performance* values in the Rocket Engine. *Engineering* values that spell greater comfort, safety and driving ease. *Styling* values, inside and out, that mean you'll drive your Oldsmobile with pride. And most important, *lasting value* . . . that holds a real pay-off for you at resale time!

Talk it over with your Oldsmobile dealer. He'll show you that *there's a Rocket for every pocket* . . . and that this is the right time to make that wonderful move to Olds!

OLDSMOBILE DIVISION, GENERAL MOTORS CORPORATION.

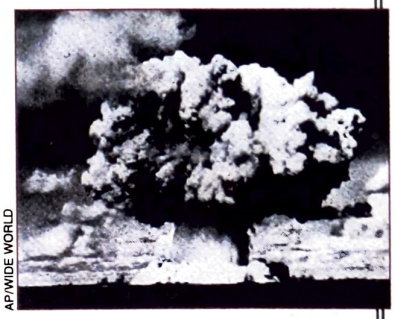
OLDSMOBILE

SEE YOUR AUTHORIZED OLDSMOBILE QUALITY DEALER

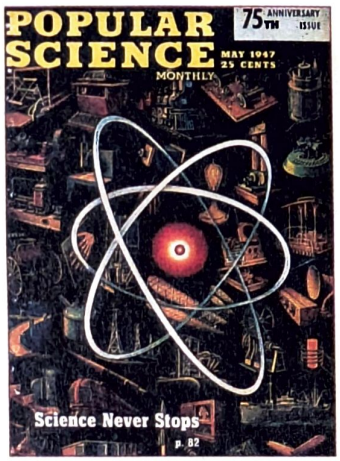
1940s

Entering the Atomic Age

To better understand the horrific weapon they had made, military officials detonated atomic bombs, including the one pictured here on Bikini atoll in the western Pacific. A POPULAR SCIENCE reporter described the haphazard damage of the blast, adding, "An atom bomb, in short, behaves even more mysteriously than a Kansas tornado."—SEPTEMBER 1946

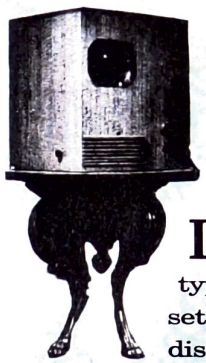


AP/WIDE WORLD



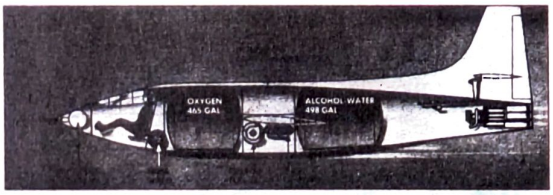
Science Never Stops

"The world has made vast strides in the last 75 years. Even greater triumphs lie ahead." At the top of the list: atomic energy, improved aviation, better nutrition, and city planning.—MAY 1947



Close to Color

Inside prototype color TV sets, a revolving disc changed the screen's picture between red, green, and blue so quickly that the human eye "fused" the images into one colorized version.—JULY 1941



Flying Faster Than Sound

Just how fast the X-1 flew was disclosed neither by Capt. Charles Yeager, the first man to fly through the sound barrier, nor by the Air Force, after the experimental craft's first flight. Yeager actually attained a speed of 700 mph.—AUGUST 1948

Spring Fling

An ordinary metal spring became the first "Slinky" toy when its inventor watched the object roll off his workbench and begin its now-famous antics on the floor.—SEPTEMBER 1946

Washers Meet Driers

The newest appliance was the gas or electric clothes-drier. "Clothes are dried in a revolving chamber through which warm air, controlled by a thermostat, is blown."—MARCH 1945

TECH NOTES

Cure For The Common Cold

Powerful electron microscopes offered the closest view yet of the unseen world. The $9,500 devices revealed the first images of the influenza virus. "There's really reason to hope that science will win its long war against influenza, the common cold, and many other ailments."•JULY 1941

Penicillin

Although penicillin was discovered in 1928, the powerful antibiotic was not widely available until World War II, when better production methods were developed. •AUGUST 1944

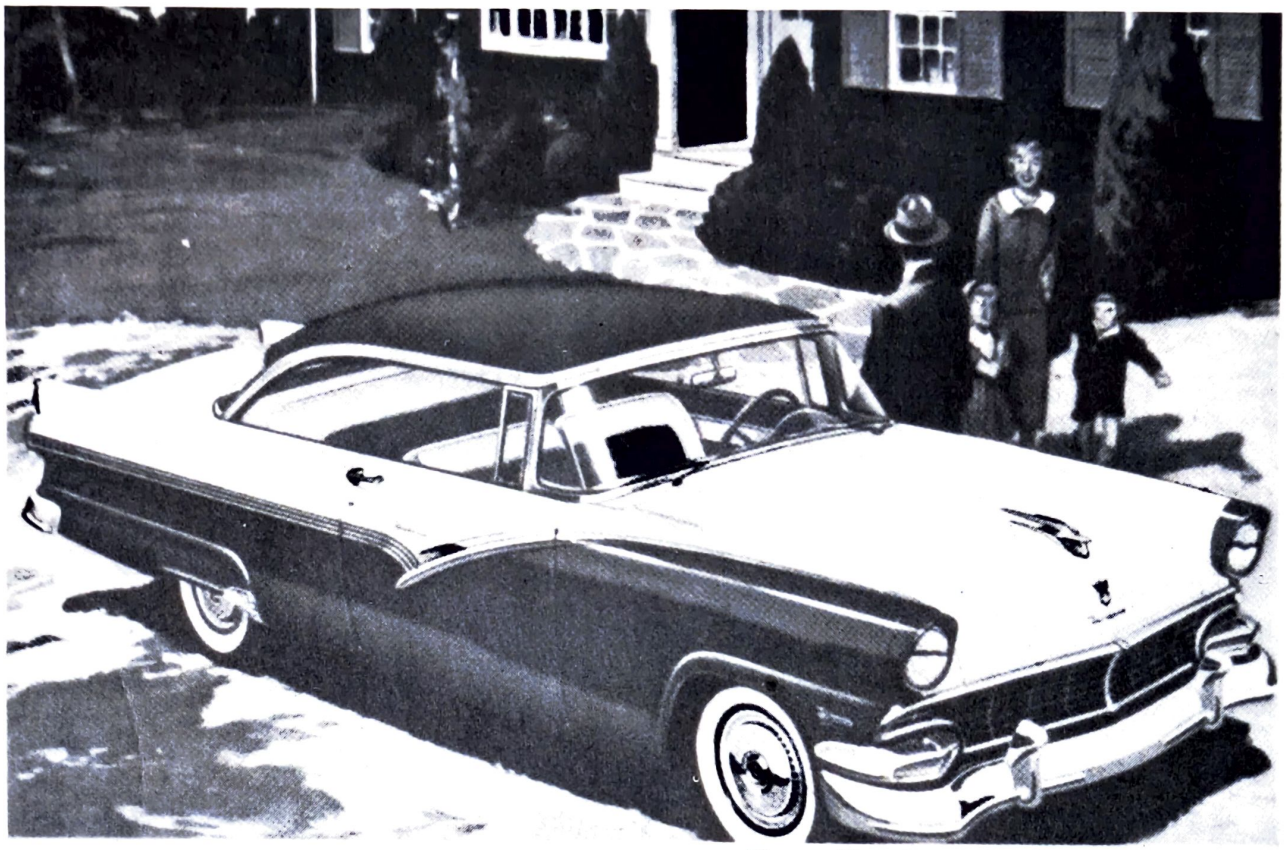
A TV in Every Home

"With 10,000 TV sets in the United States today, almost 50 manufacturers expect to market several hundred thousand in the next twelve months and millions in the next five years. Prices start at $100 and range upward to $1,000." •NOVEMBER 1945

Eniac

Roughly 1,000 times faster than its predecessors, the Electronic Numerical Integrator and Computer, or Eniac, promised to solve tough mathematical equations. Scientists hoped the results would be "cheaper air travel, better radios, wider use of microwaves, and more efficient motors."•APRIL 1946

World War II ... First atomic bomb ... Transistor invented ... Cold War begins ...



The new Victoria . . . one of Ford's 18 models for '56

You'll be safer in a '56 Ford!

For 1956, Ford announces the first major contribution to passenger and driver protection in accidents: New Lifeguard Design! It is the end result of more than two years of safety research and testing by Ford in co-operation with universities, medical associations, and leading safety experts. It is designed to give you added protection in the areas where *over half the serious accident injuries occur.*

You get this Lifeguard protection in a car unmatched for beauty . . . with styling inspired by the fabulous Ford Thunderbird. What's more, Ford brings you the sheer delight of commanding the new 202-h.p. Thunderbird Y-8 engine.* A new smooth running, Go-packed, deep-block engine that will put fresh enthusiasm into all your driving.

*Available in Fordomatic Fairlane and Station Wagon models

New Lifeguard steering wheel

Safety experts called for a wheel that would protect the driver from the steering post in an accident. The deep-center structure of Ford's new wheel provides a cushioning effect under impact.

New Lifeguard door latches

Safety experts say that passengers are safer in accidents if they stay inside the car. Ford's double-grip locks reduce the possibility of doors springing open under strain and occupants being thrown from the car.

New Lifeguard seat belts

Safety experts asked for belts to hold driver and passengers in their seats in sudden stops. Ford's optional nylon-rayon cord seat belts are solidly anchored to the steel flooring and will withstand a force of 4,000 lbs.!

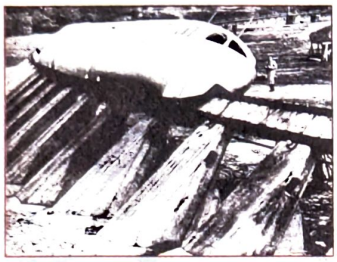
New Lifeguard padding

Safety experts recommend cushioning over hard surfaces within a car to reduce head injuries. Ford's optional Lifeguard padding over control panel and sun visors absorbs impacts . . . helps to guard you from injury.

1950s

First Color TV

The first color TV sets, introduced in 1950, could receive only color broadcasts. A CBS-Columbia console, which sold for about $500, was the first set that could receive both color and black and white pictures. After a slow start, sales of the new color TVs skyrocketed.—AUGUST 1951

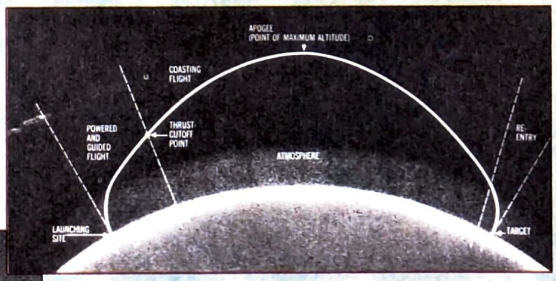


Train of the Future

Designed for speeds of up to 200 mph, a German prototype monorail was intended "to make travel on land as fast as by air." The train was stabilized by guide wheels, which contacted the rail on the top and on both sides.

Space Race

"Someday within the next two years, as you look toward the horizon in the darkness before dawn, you may see a faint spot of light moving across a moonless sky. It will be man's first milestone in space—an artificial satellite." A model of the "midget moon" appears on this cover.—JANUARY 1956



BETTMANN

The Jet Set Arrives

Boeing's 707, along with the French Caravelle, British Comet IV, and Russian TU-104, ushered in the jet era of airline travel. "Cruising at up to 600 mph, the 707 promises transport from New York to Chicago in just 1 hour and 11 minutes and nonstop service to Paris in 6 hours and 10 minutes." —AUGUST 1956

Going Ballistic

"Racing with Russia, U.S. experts are believed to be near success in perfecting the most fearsome weapon in history—the Intercontinental Ballistic Missile." The challenge was developing missiles that could withstand 10,000°F temperatures upon reentry. —AUGUST 1957

Tech Notes

The Answering Machine

"If your phone rings unanswered, your competitor may get the business." For $12.50 a month you could rent a Peatrophone, a device "that not only answers the phone in your voice, but also takes messages." •MAY 1953

Disease Fighters

Cures for two dread diseases came in the form of isonicotinic acid hydrazide for tuberculosis and the Salk vaccine for polio. "Polio researchers have developed a safe and inexpensive vaccine that one day will give long-time protection against this disease." •MAY, DECEMBER 1953

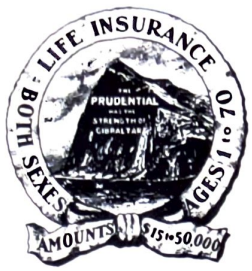
First Nuke

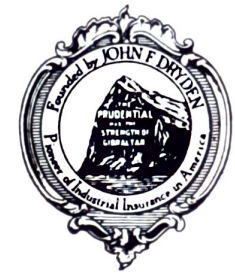
"Twelve years after Hiroshima, a full-scale electric utility plant using nuclear energy purely for power will be a reality." The first plant, located in Shippingport, Pa., was expected to generate about 60,000 kilowatts —enough power for 250,000 people. •SEPTEMBER 1956

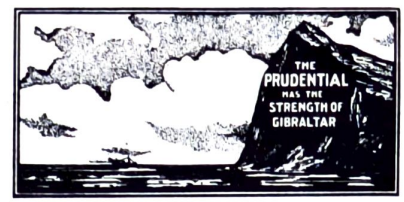
Grip Strip

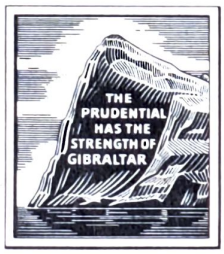
"Here is a nonmetallic fastener with no mechanical parts. It is simply two strips of nylon, one woven with thousands of tiny protruding hooks, the other with loops." It was Velcro, an invention that has been used in everything from shoes to astronauts' gloves. •DECEMBER 1958

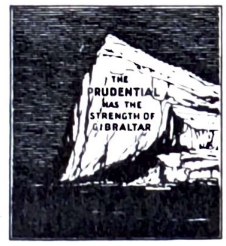
Hydrogen bomb tested ... The first space satellites ... U.S. ballistic missiles ...

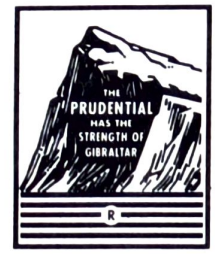












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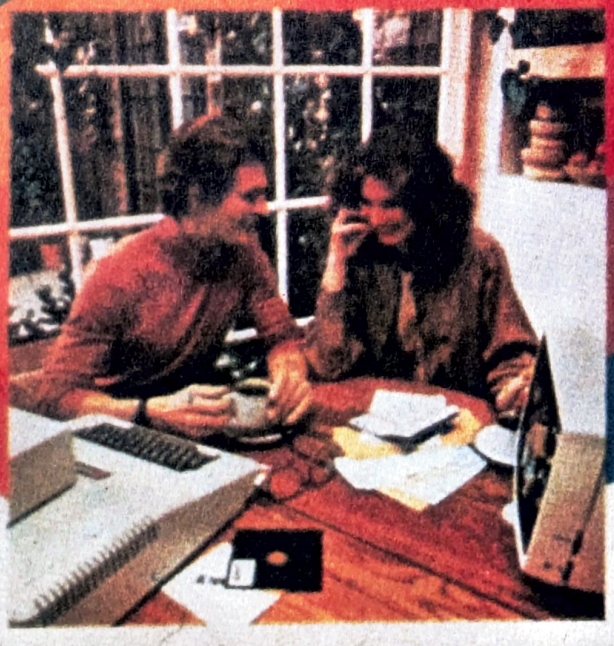
A is for Apple.

It's the first thing you should know about personal computers.



Discover the special thrill of personal computing—with Apple! It's a home computer, a business computer, a classroom computer, *your* computer. No wonder tens of thousands have already chosen Apple. Join the excitement in your local computer store. Call for the one nearest you. **800-538-9696.** In California call **800-662-9238.**

apple computer

10260 Bandley Drive
Cupertino, CA 95014

Cream of the '59 crop *CHEVY*

Harvest hauls are bound to be more profitable with Chevrolet's bright new might on the job. Here are just a few of the reasons why you can depend on Chevy to hustle you to market right on time, every time, and to save you money all along the way.

New, thriftier 6's and economical V8's. Chevrolet engines squeeze the last penny's worth of power out of every dollar's worth of gas! The new Thriftmaster 6, for example, cuts fuel costs by up to 10% with a new economy-contoured camshaft. And Chevrolet V8's are extra-efficient cost-cutters, too, with the shortest piston stroke of any comparable truck V8 on the market!

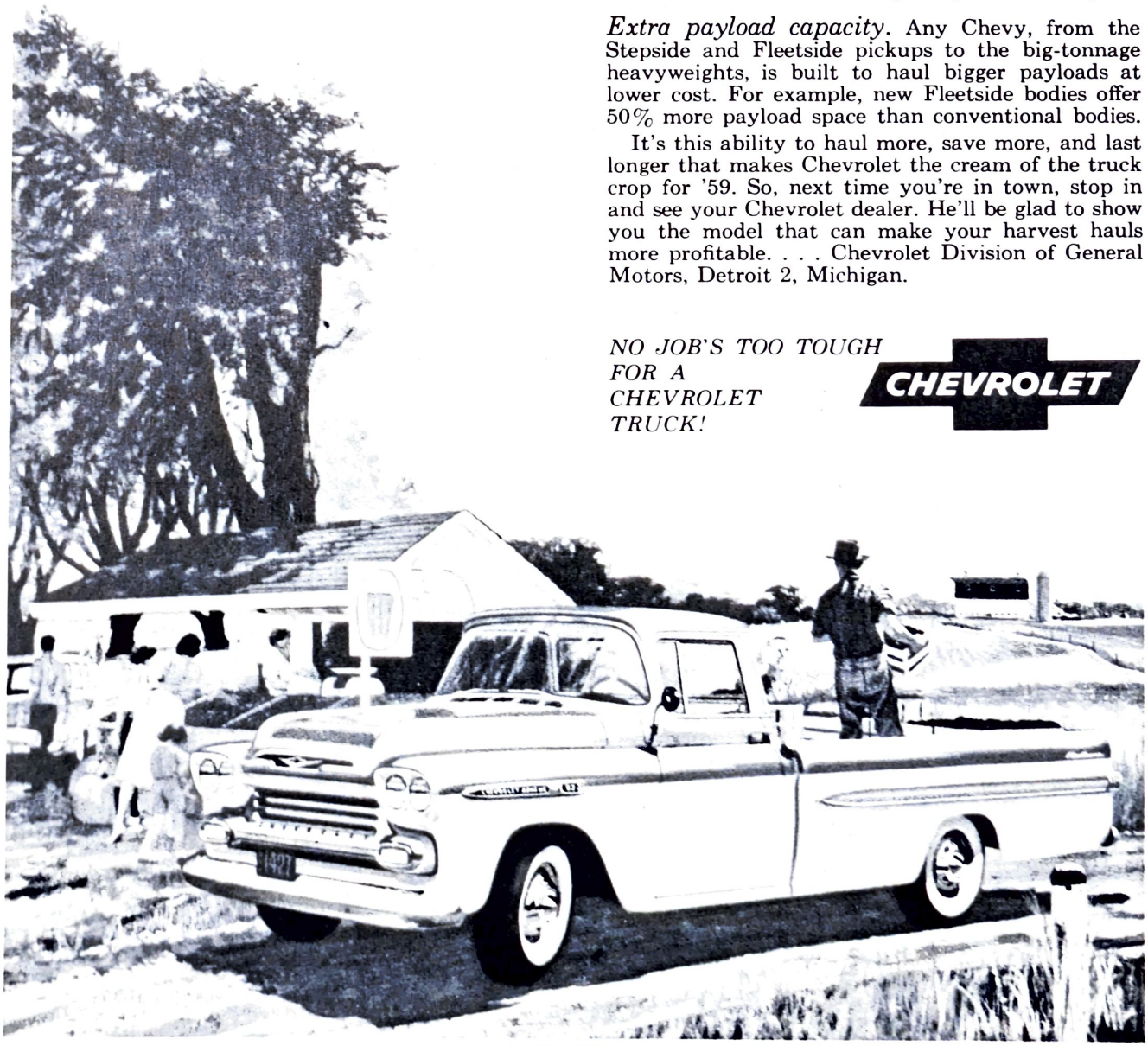
Dependable, tough-built chassis. Moving big harvest loads to market right on time calls for trucks with real stamina; *tough* trucks that can keep going around the clock, on the road or in the fields. That's Chevy's kind of stamina, the result of extra ruggedness engineered into every component. You get a brawny frame of premium steel, extra big brakes, high-capacity axles and springs, smooth Synchro-Mesh transmissions, and solid Unitized cab construction that stands up to jounces and jolts.

Extra payload capacity. Any Chevy, from the Stepside and Fleetside pickups to the big-tonnage heavyweights, is built to haul bigger payloads at lower cost. For example, new Fleetside bodies offer 50% more payload space than conventional bodies.

It's this ability to haul more, save more, and last longer that makes Chevrolet the cream of the truck crop for '59. So, next time you're in town, stop in and see your Chevrolet dealer. He'll be glad to show you the model that can make your harvest hauls more profitable. . . . Chevrolet Division of General Motors, Detroit 2, Michigan.

NO JOB'S TOO TOUGH FOR A CHEVROLET TRUCK!

CHEVROLET



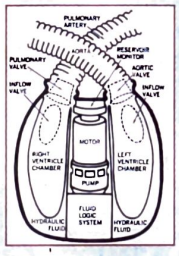
1960s

POPULAR SCIENCE
MARCH • 35¢ Monthly
AMAZING NEW AUTO ENGINE
10,000-Mile Test: VALIANT vs. CORVAIR and FALCON
Also FREE BLUEPRINT
Ball-Turning Tool for Your Machine Shop

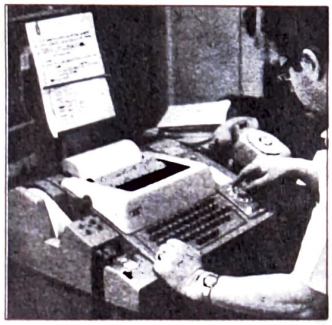
Hopes for the Rotary

Describing the Wankel engine as "a cross between the ordinary internal-combustion engine and the turbine," a cover story reported that the German-built rotary engine was a "hot possibility" for lawn mowers, outboard motors, chain saws, and motorbikes, as well as cars.—March 1960

The Artificial Heart

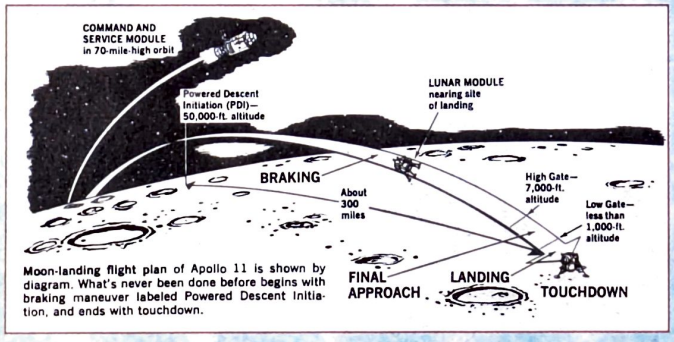


Heart transplants made medical headlines, although "some experts believe that the ultimate solution in heart cases will be a completely artificial, rather than a transplanted, heart." An electrically powered version designed by Indiana University physicians was slightly larger than a human heart.—April 1968



Home Computer

A writer used a teletype machine in his home to communicate with a mainframe computer on a time-share basis—then thought to be "key to the computer's future." "Personal" computers, experts predicted, would never be affordable to individuals.—May 1967



Moon-landing flight plan of Apollo 11 is shown by diagram. What's never been done before begins with braking maneuver labeled Powered Descent Initiation, and ends with touchdown.

"One Small Step for Man . . ."

On July 20, 1969, Apollo 11 commander Neil Armstrong climbed out of his lunar module and stepped onto the moon. A moment-by-moment account of the mission let readers follow the action.—July 1969

A Phone With a View

A cross between a TV and telephone, Bell System's Picture-Phone let users see each other as they talked. The service was available between stations in New York, Washington, D.C., and Chicago, as well as at the New York World's Fair and Disneyland.—August 1964

Tech Notes

Tinkering With DNA

Scientists at Harvard unzipped coils of bacterial deoxyribonucleic acid—or DNA—and then reassembled them in a different order, creating new organisms. These techniques may lead to "better foods, flowers, cattle, or creations unimaginable now." •January 1961

The VCR Arrives

"Tape revolutionized TV broadcasting. Now it's going to revolutionize TV watching." Not only could you use the British-made reel-to-reel equipment to record your favorite shows, but you could also connect it to a video camera for home movies.•October 1963

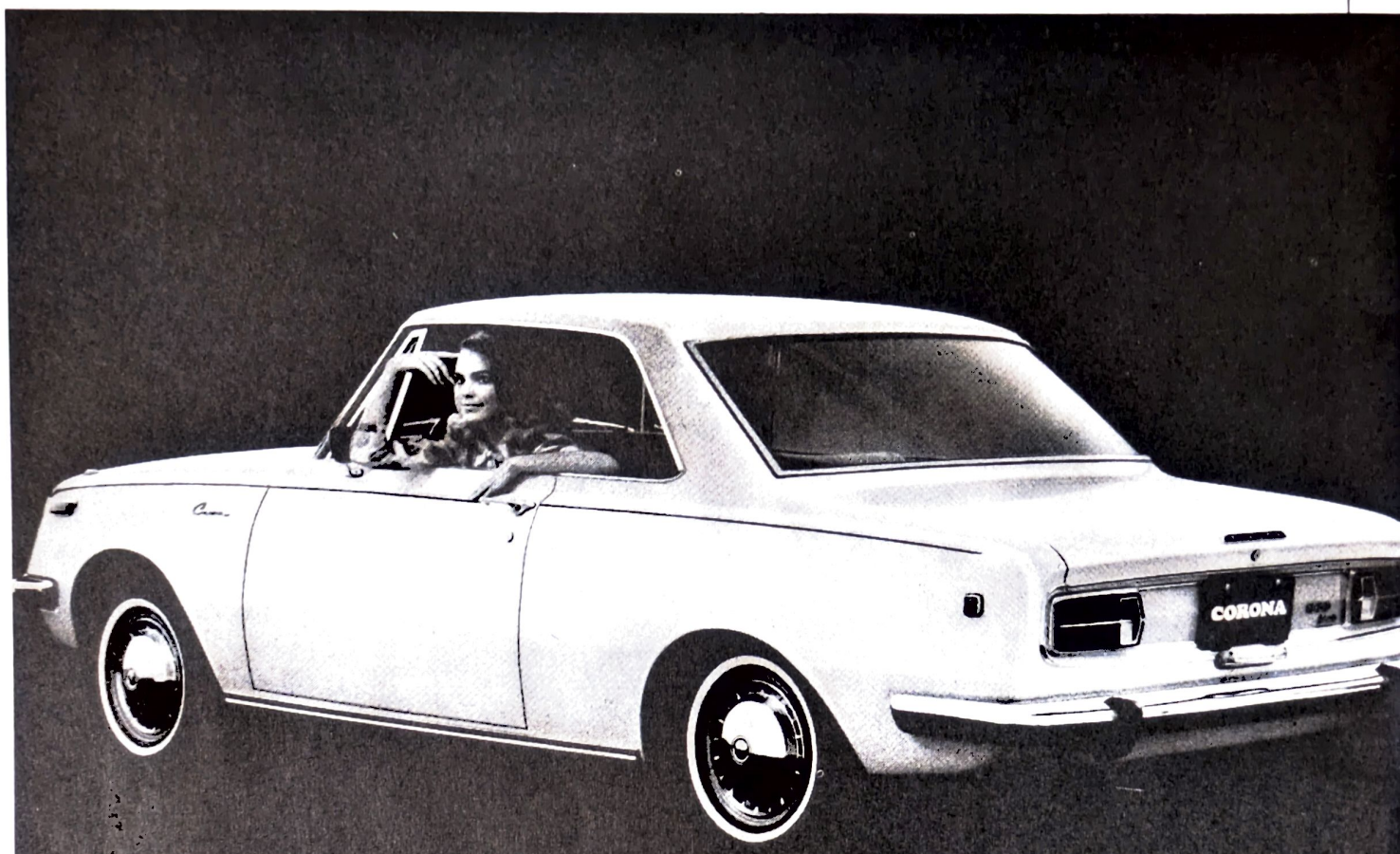
Affordable Microwaves

Although microwave ovens had been invented years earlier, they didn't hook consumers until 1966, when Tappan introduced a free-standing electric oven with a built-in microwave. It was praised for cooking food quickly without heating the dish.•March 1966

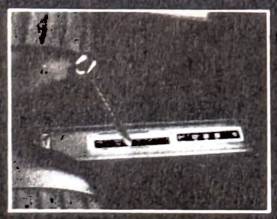
Atomic Anxiety

Ban-the-bomb: Novelist Fletcher Knebel urged scientists to unite and pressure politicians into disarming nuclear stockpiles. The threat of the bomb, he wrote, created a "curious feeling of monstrous unreality."•December 1968

U.S.S.R. puts first man in space ... NASA lands astronauts on the moon ...



One more thing Toyota gives you is a fully-automatic automatic*



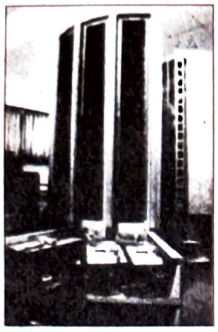
When we say "automatic," we mean **fully** automatic! No stick. No clutch. No compromise. It's a transmission that shifts for itself! And even with an automatic, Toyota Corona zips from zero to sixty in 16 seconds. Tops 90 mph. Mileage? Still about 25 miles or more per gallon. What else does Toyota Corona give you? Reclining bucket seats; wall-to-wall Nylon carpeting; loads of luxury and safety features . . . and a ride that lets you relax and enjoy it. So relax and enjoy it.

Get your hands on a Toyota . . . you'll never let go.

TOYOTA
CORONA

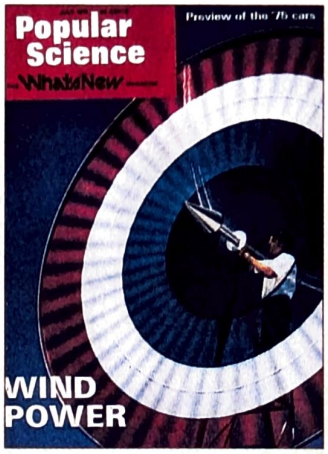
TOYOTA, Japan's No. 1 Automobile Manufacturer
Toyota Motor Distributors, Inc., Main Office, 2055 West 190th St., Torrance, Calif. 90501
Eastern Office, 231 Johnson Ave., Newark, N.J. 07108 Mid Southern Toyota Ltd., 1640 North LaSalle St., Chicago, Ill. 60614

1970s

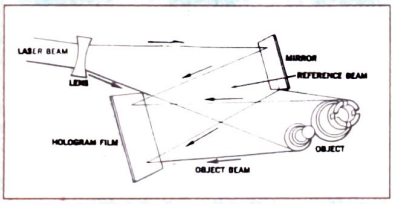


Supercomputer

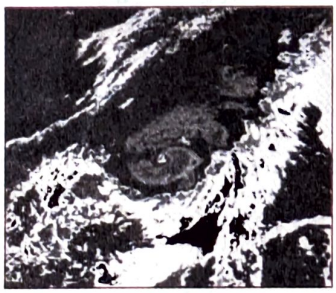
The Cray-I, the first of the supercomputers, covered 70 square feet and operated at 80 megaflops. It was considerably faster than either the Cyber 176 or IBM 360/195 computers, which were considered superfast at four to seven megaflops.—June 1979



The Hologram



In the 100th anniversary issue, Dennis Gabor described how he discovered holography. "It is a nice example of serendipity," Gabor wrote. He had received the Nobel Prize in Physics for the discovery the previous year.—May 1972

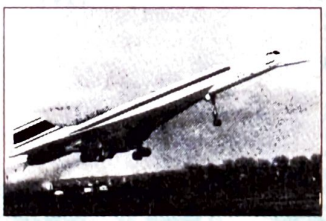


Satellite Advances

Increased capabilities of weather satellites helped fishermen, pilots, and water-resource planners. The military planned to launch the first satellite of a 24-satellite Global Positioning System. —September 1974

Blowing in the Wind

The energy crisis focused attention on alternative power sources, including an innovative "bicycle wheel" wind turbine. "Five years seems to be the shortest development time before serious efforts to incorporate wind into the national energy picture can be expected."—July 1974



BETTMANN

Aboard the Concorde

"You'd never know it's Mach 2. Between the pilots I could see the four throttles that unleashed enough thrust to make the 204-foot delta-wing giant practically stand on its tail."—October 1973

Exploring the Invisible

The scanning electron microscope "is undoubtedly the most important advance in revealing the world of the invisible since the invention of the electron microscope 40 years ago." The flat world of the submicroscopic had at last become three dimensional. —April 1970

Tech Notes

LCDs

"The possibilities seem endless for liquid-crystal-display technology—calculator displays, windshield sun visors, electronic window shades, and even flat-screen TVs."•February 1972

Superconductors

Superconductivity became more than a laboratory curiosity when a projection of electricity savings was calculated. "If this country doesn't switch to superconductive transmission lines during the next 20 years, the energy wasted as heat in the wires will be equal to all the electricity generated in the United States today."•October 1974

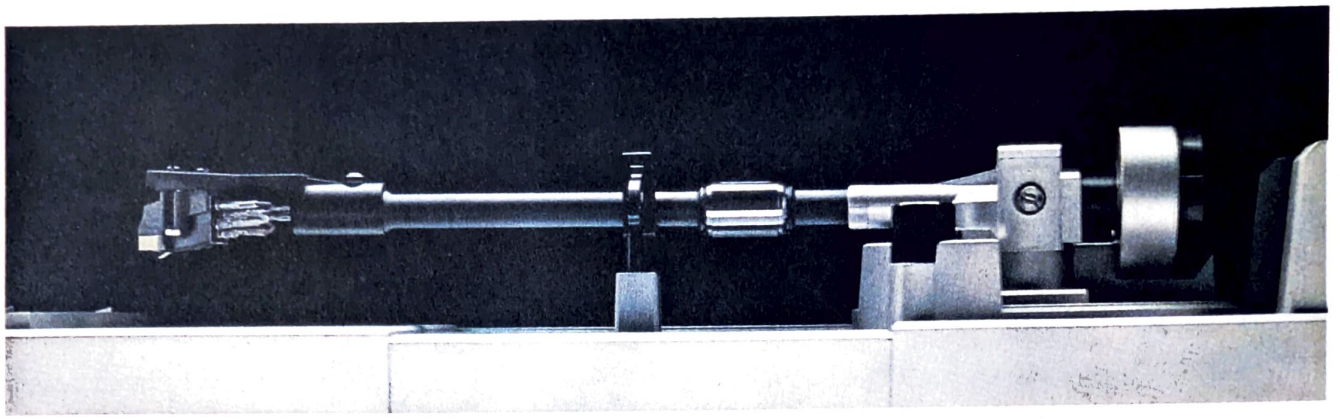
Laser Checkout

"Large supermarkets have started using bar-code scanners to ring up grocery bills, but they are expensive, bulky, and delicate. A new generation of scanners sports rugged semiconductor lasers, which are bringing the devices to stores near you."•April 1975

Ozone Debate Begins

"It has been a little more than two years since two scientists at the University of California said that we could be destroying the earth's fragile ozone layer with chemicals called fluorocarbons. It is not comforting knowledge." •June 1977

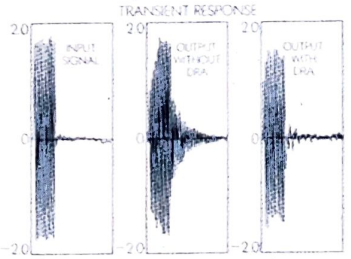
First Earth Day ... Oil embargo ... Three Mile Island reactor accident ...



HERE'S A TECHNOLOGY STORY THAT'S TRULY ABSORBING.

Every story has a protagonist and an antagonist. And this one's no different.

The hero, in this case, is an unassuming, little technological breakthrough from Pioneer called the Dynamic Resonance Absorber™ (DRA).



And the arch-villain, the ever-present Resonant Tonearm Vibration.

What the Dynamic Resonance Absorber does, to make a long story short, is to absorb the resonant frequency of the tonearms on all of our new turntables.

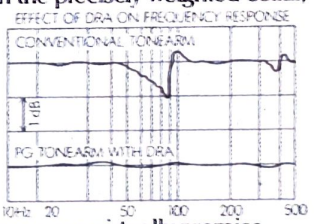
Thereby eliminating distortion which causes music to lose clarity and accuracy of reproduction.

As if this weren't thrilling enough, there's also an exciting subplot. The DRA eliminates acoustic feedback that results when the turntable is too close to speakers played at high volume.

How the Dynamic Resonance Absorber causes all this to happen is actually quite simple, as most acts of genius usually are.

The DRA is composed of a damper made of extremely dense butyl rubber enclosed in a weighted collar on the tonearm.

Working within the precisely weighted collar, the butyl rubber acts just like a spring. When the pipe of the Polymer Graphite™ (PG) tonearm vibrates, the "spring" compresses and simultaneously soaks up vibrations.



That's why Pioneer can virtually promise that muddy reproduction is an out-of-date story. And why transient response is far more accurate. In fact, as you can see on the chart, the cartridge output (with DRA) closely resembles the original input.

Furthermore, frequency response, as you can also see, is tremendously flat.

But, while the Dynamic Resonance Absorber is a real blockbuster, it's not the only story here.

Every Pioneer turntable also features a Stable Hanging Rotor™ that improves stability by reducing friction which decreases wow and flutter.

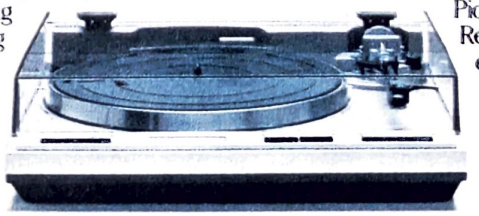
A zero-clearance dust cover allows you to place the turntable flush against a wall, yet still open it all the way.

And another convenience item: all controls are located outside the dust cover.

In addition, the PL-S70 (shown here) has two other ease-of-operation features: an automatic disc size selector (ADSS) and auto repeat function.

Naturally, you'll want to audition each new Pioneer turntable with Dynamic Resonance Absorber at your earliest convenience.

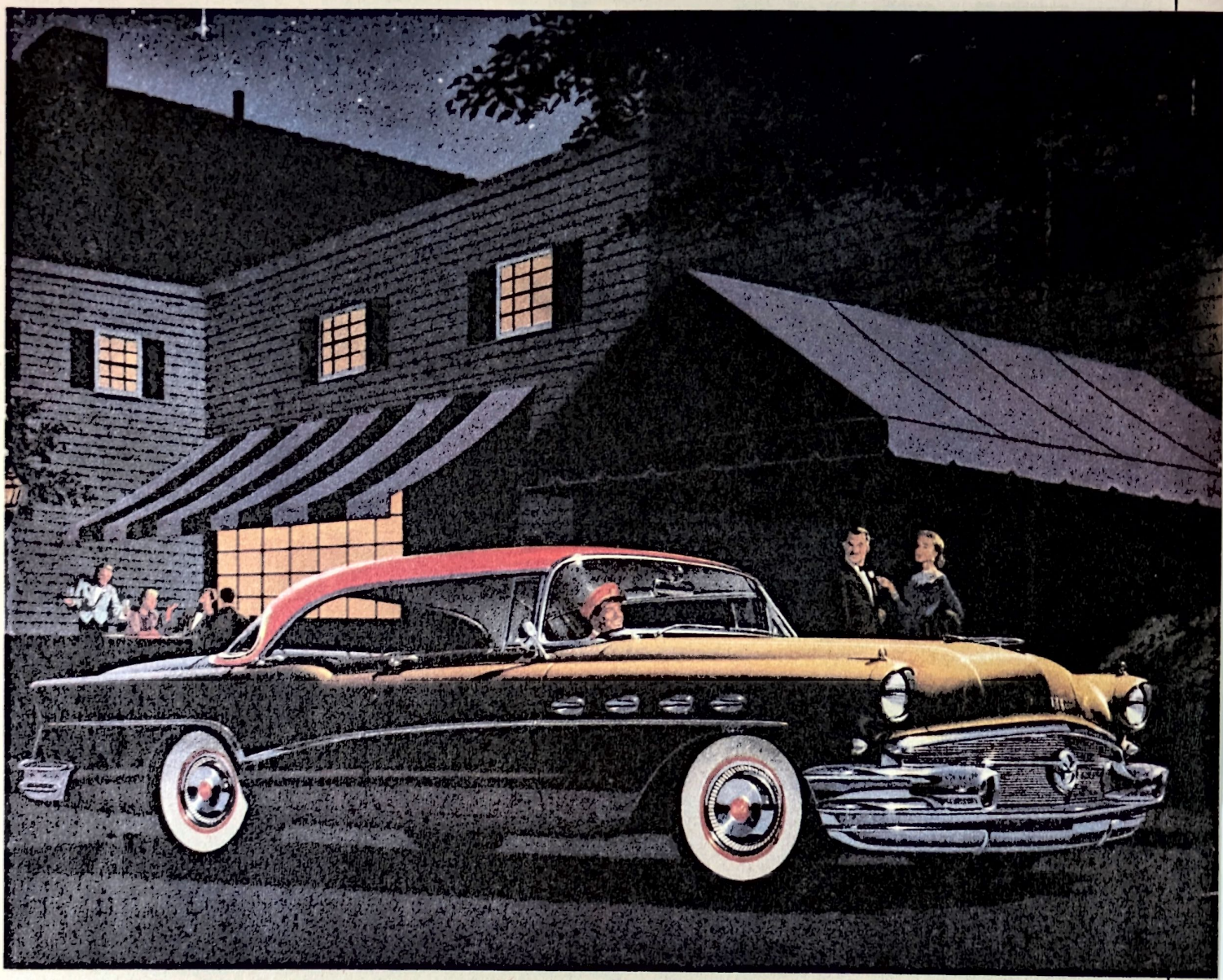
If only to convince yourself that this story falls in the non-fiction, not the science-fiction category.



PIONEER
Because the music matters.

© 1983 Pioneer Electronics (USA) Inc., P.O. Box 1540, Long Beach, CA 90801

Lee Rider Jeans and Jackets. H. D. Lee Company, Inc., P. O. Box 440-B, Shawnee Mission, Kansas 66201 • Available Worldwide A company of VF corporation



Symbol of more than success

THERE are those who feel they must prove their success—while others simply live theirs.

One man will buy the costliest of fine cars as evidence of his position—another will buy a fine car for the fineness of the car itself.

And among those who weigh matters on worth alone, ROADMASTER is winning unprecedented preference—for good reason.

It is not, you see, the costliest of fine cars.

But it *is* the costliest of Buicks—which gives this automobile a matchless merit.

For, as the very cream of the Buicks that have climbed to record popularity, ROADMASTER begins with the many qualities that have soared Buick to such success—and moves on to its own eminence.

So here you have the great Buick ride brought to a masterful new peak of solidity and smoothness.

Here you have Buick sureness of handling raised to a new level of consummate ease.

Here you have the bigness and comfort of Buick interiors detailed to striking new luxury, with fabrics and metal harmonized in vibrant colors and exquisite elegance.

Here you have a stunning exterior of long, lithe lines crowned by individualized style distinctions reserved exclusively for this Buick of Buicks.

And here you have, spreading beyond it all, the silken and commanding action of this precisely named motorcar.

For ROADMASTER is powered to a new peak of V8 brilliance, and winged by the spectacular smoothness and performance of Buick's advanced new Variable Pitch Dynaflow—the most modern transmission yet brought to the American scene.

Perhaps *you* belong in a ROADMASTER, custom-appointed to your order.

See your Buick dealer soon for an inspection of the finest ROADMASTER yet.

BUICK *Division of* GENERAL MOTORS

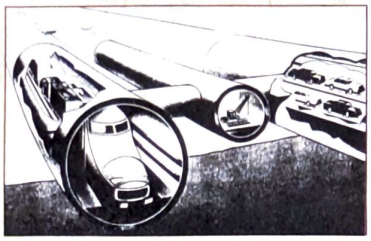
ROADMASTER

Custom Built by Buick

When better automobiles are built Buick will build them

1956

1980s



At Last: Chunnel for the Channel

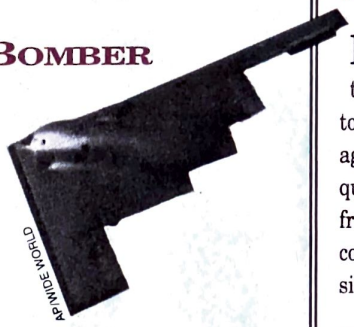
After 200 years of false starts and abandoned plans, the Chunnel project—an under-the-English-Channel link between France and Britain—finally got under way. Electric trains are scheduled to zip through the 31-mile twin tunnels starting in 1993.—May 1986

Popular Science
the What's New magazine
PS buyer's guide: the new CORDLESS PHONES
Safer skies into the 21st century: FAA'S REVOLUTIONARY CONTROL SYSTEM
THE AMAZING WINCHESTER Big-machine memory for personal computers
INSIDE THE '83's How GM, Ford, AMC, and Chrysler meet the challenge
SPECIAL HEATING SECTION:
•Catalytic wood stoves
•Kerosene heaters
•Relining a chimney
Engineering secrets of the new
SMART MISSILES

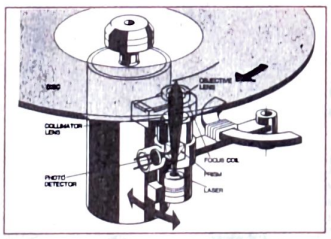
On Target

The battle for the Falkland Islands demonstrated the deadly accuracy of "smart" missiles. Guided by laser, radar, or heat, the missiles revolutionized modern military tactics. —October 1982

Invisible Bomber



To enemy radar, the stealthy bomber under development looked like a hummingbird: Its radar cross section was one-millionth of a square meter. "The plane is certain to be low-slung and squat, almost like a Frisbee in proportions."—February 1983



Digital Audio

"Compact discs, revolutionary new music-playback media, deliver dazzling high fidelity—without clicks, pops, hiss, wow, or flutter," reported audio expert Leonard Feldman. "My guess is that the no-wear laser-playback compact disc will become a world standard."—November 1981

Don't Skid Around

Antilock braking first appeared on U.S. cars in 1985. The system automatically pulsed the brakes in split-second intervals. "It is the most important auto-safety development of the decade."—November 1984

Shuttle to Space

"A reusable spacecraft will do more than cut launch costs. Easy access to a world of zero gravity may transform the way we do things," such as improving satellite communications, manufacturing pharmaceuticals, and growing crystals.—August 1981

Tech Notes

Portable Music

"Imagine skiing to Stravinsky or skating to your favorite disco beat," suggested an editor who tried out a portable tape player and headphones. Sony's Soundabout cost $199.•July 1980

Someday HDTV?

Prototype high-definition television dazzled the editors with its brilliant images. But the technology required considerably more frequency spectrum than conventional TV transmission.•November 1981

Word Processing

Thanks to word-processing software, home computers could become "the most flexible electronic 'typewriter' you've ever used."
•February 1982

Bacteria Snack on Toxic Waste

Bacteria that consume sulfur toxins found in coal and oil were hailed as an inexpensive way to dispose of hazardous wastes.
•September 1983

Cold Energy?

"Hydrogen fusion at room temperature? The notion sounds absurd. But recent experiments show that a scheme for cold fusion may just be possible." The claim by Brigham Young University researchers is still being debated.•April 1987

Space shuttle launched ... Chernobyl reactor disaster ... *Glasnost* begins ...

A new hammer free if this

This hammer is a Sears, Roebuck and Co. Four-Star Value. It is unconditionally guaranteed to give satisfaction or Sears will replace. This is just one reason the hammer is a Sears Four-Star Value. Read 8 other reasons.

THERE are over 200,000 items in the Sears Catalog. Each is an excellent value or it wouldn't be there. But one out of every 1,400 of these items is a *fantastic* value. It is called a Sears Four-Star Value. This means it has been picked by a jury of 21 hypercritical Sears merchants, to represent the *141 most amazing values at Sears.*

The jury picked the hammer in the picture to be a Four-Star Value. The verdict was based upon this evidence:

1. Like a golf club, baseball bat, or tennis racket, this Sears hammer was designed with the correct feel, weight, and *balance* to give it maximum striking force at impact.

$5.00. *A fantastic value! You'll find this hammer and other Craftsman tool values at Sears during SEARS NATIONAL HARDWARE WEEK—MARCH 14 TO 23.*

Sears Four-Star Value ever breaks

2. This is the only hammer made with reinforced claws. Thirty men together could not apply enough pressure to break them.

3. A "V"-shaped nail slot in the edge of the left claw lets you pull out nails in tight corners where ordinary hammers are useless.

4. The striking face is machined and crowned to hit the nail squarely. It is beveled to minimize chipping.

5. The steel head was drop-forged for enormous strength. A jet aircraft's landing gear is drop-forged for the same reason.

6. The Sears laboratory reports the tubular steel handle of this hammer withstood forces that *broke* all other handles tested.

7. A patented hickory plug assembly is inside the steel handle. This assembly absorbs shock and locks the head to the handle.

8. The neoprene grip is permanently bonded to the handle. It is resistant to oil and grease, and will not conduct electricity.

The Sears hammer costs $5.00. If you buy it, you will never have to buy another one unless you lose it. It is one of the most outstanding values you can find—at Sears or anywhere else in the world. And remember, you can always charge it at Sears.

When you are at Sears during Sears National Hardware Week (March 14 to March 23) look for the Four-Star Value seal. It's the fastest way to *shop at Sears and save.*

This Wonderful Gardening Machine is such a JOY to use...

You'll want to have twice as big a vegetable garden as you now have!

You'll want to start a vegetable garden if you don't now have one!

WITH food prices and other living costs, including taxes, constantly rising, many thousands of people who have gardens are increasing their size—to grow more vegetables and fruit . . . and many thousands of people who haven't had vegetable gardens are now starting them.

What good news it is, therefore, that there is now a wonderfully **different** and **better** kind of Rotary Tiller that makes gardening much easier and simpler than it has ever been before — so that having a **large garden**—one that can produce **hundreds of dollars** worth of delicious eating a year — is now actually **easier** than having a **small** garden was before.

This wonderfully **different** and **better** gardening machine is such a joy to use that even youngsters, ladies and older folks can handle it with ease!

WHAT'S THE SECRET ?

Please see top photo at right, and note that our Tiller, the TROY-BILT® has its revolving blades in the REAR. It has power in the wheels. It is so easy to handle you literally guide it with just ONE HAND! The machine does the work. All you do is guide it. You **don't** have to walk behind it. You leave NO footprints in the soil you have just tilled or cultivated! The machine leaves NO wheelmarks!

Now, please see lower drawing of the type of Tiller which is so difficult to use—but which has been widely sold in recent years because it is somewhat cheaper to build.

This Tiller has its revolving blades in FRONT. It has no power **in the wheels. Not only does it do** a poor job of tilling, but you have to hang on for dear life with BOTH HANDS! This means you have to walk squarely behind it, tramping on the nice smooth soil you have just tilled or cultivated — causing weed seeds to germinate more quickly. This machine also, of course, leaves wheelmarks—again causing weed seeds to germinate more quickly. Worst of all, nobody can really **enjoy** using a FRONT END Tiller!

SO . . .

—if you now have a garden, and have been using a FRONT END Tiller, please mail the coupon below, so that we can tell you the **whole** wonderful story of TROY-BILT® Roto Tillers, including prices and off-season savings now in effect for a limited time. We **guarantee** you'll never want to use a FRONT END Tiller again once you try a TROY-BILT® Roto Tiller!

If you don't now have a garden, you, too, are invited to mail the coupon . . . to find out how easy it is to garden with a TROY-BILT® Roto Tiller . . . how much money you can save by growing your own vegetables, strawberries, etc.; how different and good they taste compared to what you buy in stores; how relaxing gardening can be -- how much joy even for youngsters, ladies and older folks if they have a TROY-BILT® Roto Tiller to use-

TROY-BILT® Roto Tillers
Troy, N.Y. 12180

PLEASE MAIL THIS COUPON NOW!

Just one hand !

Now in its 14th great year, the TROY-BILT® Roto Tiller was designed and is built by the builders of the famous ROTOTILLERS. This latest and best of them all, with more than 35 years of Tiller building experience behind it, makes gardening much easier than ever before — far, far easier than with the type of Tiller shown below, which has only its somewhat lower cost to recommend it. Please mail coupon below for the *whole* wonderful story of the TROY-BILT® Roto Tiller!

Torture !

Using *this* type of Tiller, with its revolving blades in FRONT is TORTURE compared to the JOY of using a TROY-BILT® Roto Tiller, with its revolving blades in the REAR, as shown at top. Please mail coupon below for the *whole* wonderful story of the TROY-BILT® Roto Tiller.

TROY-BILT® Roto Tiller-Power Composters
GARDEN WAY MFG. CO., INC., Dept. 50213
102nd St. & Ninth Ave., Troy, N.Y. 12180

Please send the **whole** wonderful story of TROY-BILT® Roto Tillers, including prices and off-season savings now in effect for a limited time.

Name .....

Address .....

City .....

State ..... Zip .....

"Imagine me, steering a Destroyer!"

"And I've had two pay raises in only eight months! I'll say you can't beat Uncle Sam's Navy!"

YOU couldn't ask for a greater thrill than that which a fellow gets when he comes back home wearing a trim Navy uniform. The folks crowd around. They all want to know where you've been, what you've done. And man, do you have stories to tell!

GREATEST LIFE IN THE WORLD

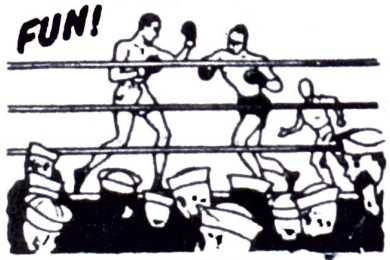
You're proud. And you should be. For you've been leading the greatest life in the world. And it's a thrill to tell about it, too. A thrill to see the admiration in the eyes of the One and Only Girl as you tell about the first time you steered a Destroyer. Or handled a P.T. Boat at more than 45 miles per hour. Or stepped out in front of your shipmates to receive your first promotion.

And with that promotion came an increase in pay. And there were more to come. Second Class. First Class. And then Chief Petty Officer. You might even go to Annapolis. Or to Pensacola with the flying cadets!

Exciting? You bet, and fun too. Something doing all the time. Real he-man's stuff. Boxing. Baseball. Football. Swimming. AND MOVIES... previews, too!

FREE TRAINING WORTH $1500

And all this time you're taking care of your future! The Navy said, "Pick a trade—we'll make you an expert." And they gave you



LOOK WHAT THE U. S. NAVY OFFERS YOU

FREE TRAINING worth $1500. Nearly 50 trades and vocations to choose from.

GOOD PAY with regular increases. You can earn up to $157 a month.

EACH YEAR you are entitled to a generous vacation period, with full pay.

GOOD FOOD and plenty of it.

FREE CLOTHING. A complete outfit of clothing when you first enlist. (Over $100 worth.)

FREE MEDICAL CARE, including regular dental attention.

FINEST SPORTS and entertainment any man could ask for.

TRAVEL, ADVENTURE, THRILLS—You can't beat the Navy for them!

BECOME AN OFFICER. You can work for an appointment to the Naval Academy or the Annapolis of the Air at Pensacola.

FUTURE SUCCESS. It's easy for Navy trained men to get good-paying jobs in civil life.

LIBERAL RETIREMENT-PAY.

nearly 50 skilled trades and vocations to choose from: Radio expert, machinist, welder, aviation mechanic, dental technician, electrician—to mention a few.

Yes, training that would be worth $1500 to you in one year's time. Training that will assure you of a well-paid job in civil life. Yet you get paid while learning—get your keep and a complete outfit of clothing free.

Where else in the world are there such opportunities for thrill, for fun, for a future as in Uncle Sam's Navy!

ACT NOW! HERE'S HOW!

(No Obligation)

TODAY . . . get the free illustrated booklet called "Life in the Navy." It gives you the glowing facts. All you need do is to ask the Navy Editor of this newspaper for a copy.

TELEPHONE HIM, or fill in the coupon below and give it to him at this newspaper's office. Or mail the coupon to him, either in an envelope or pasted on a penny postal card.

WEAR THIS BADGE OF HONOR! If after reading the free booklet you decide to apply for a place in the Navy, you will receive this smart lapel-emblem. It is a badge of honor you will be proud to wear.

★ **SERVE YOUR COUNTRY**

★ **BUILD YOUR FUTURE**

★ **GET IN THE NAVY NOW**

Tear out and take or send this coupon to the Navy Editor of this newspaper

Without obligation on my part whatsoever, please send me free booklet, "Life in the Navy," giving full details about the opportunities for men in the Navy.

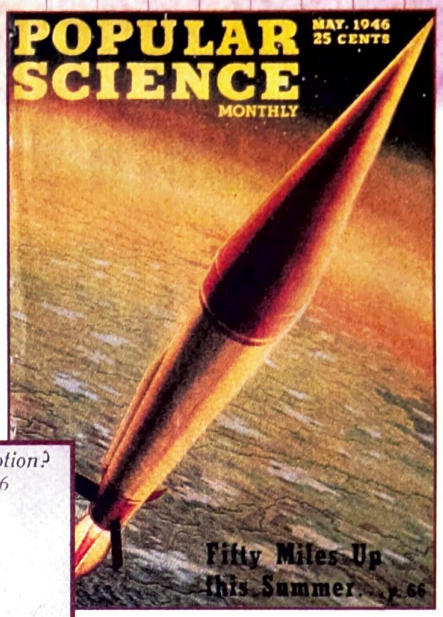
Name_____

Address_____

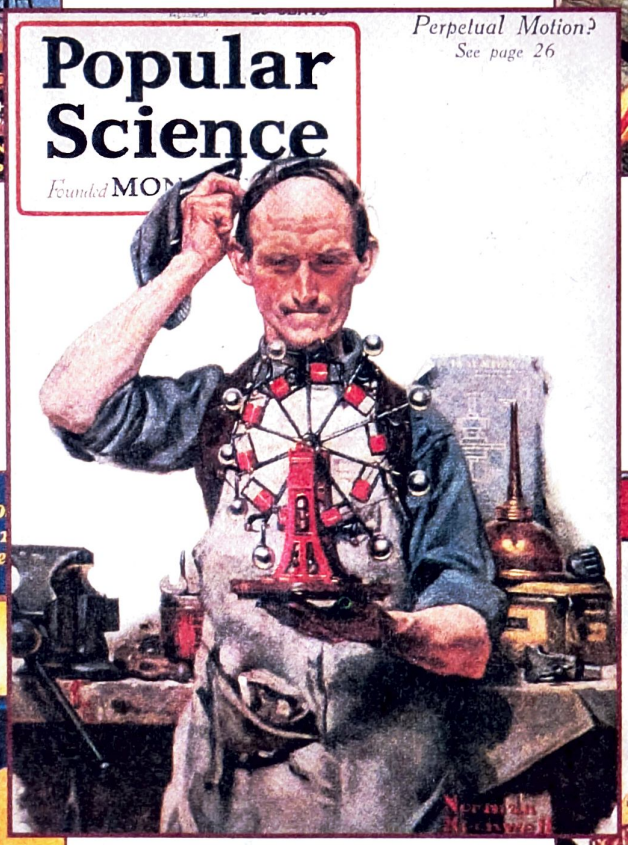
_____

1939

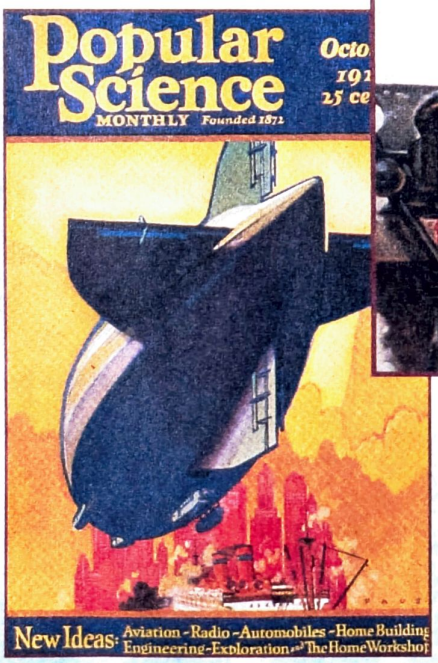
OCTOBER 1934
Edgar Franklin Witmack



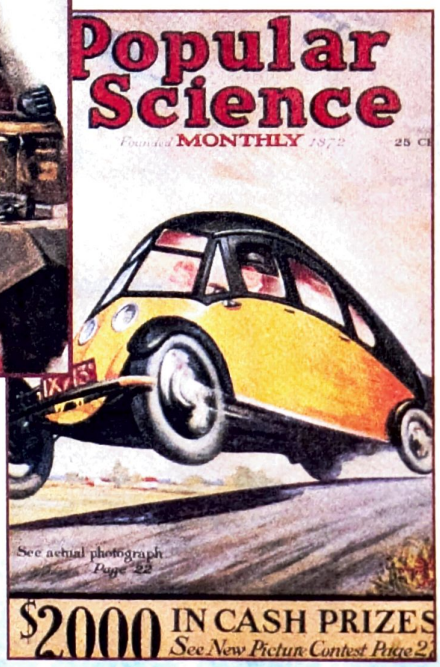
MAY 1946
Ray Pioch



OCTOBER 1920
Norman Rockwell


Popular Science
MONTHLY Founded 1872
New Ideas: Aviation - Radio - Automobiles - Home Building
Engineering - Exploration and The Home Workshop

OCTOBER 1928
Paus



DECEMBER 1930
Edgar Franklin Witmack

JUNE 1933
Edgar Franklin Witmack

Norman Rockwell illustrated the October 1920 cover of POPULAR SCIENCE. This month's anniversary cover is a collage made up of the other five covers shown on this page.

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Every NRI course features practical, hands-on training with state-of-the-art equipment you keep. Only NRI gives you the training *and* the equipment for career advancement, part-time earnings, or even a business of your own.

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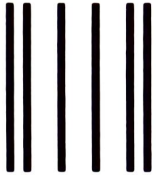
- ☐ Telecommunications
- ☐ Industrial Electronics & Robotics
- ☐ Digital Electronics Servicing
- ☐ Radio Communications (FCC)
- ☐ Cellular Telephone Technology
- ☐ Security Electronics
- ☐ Electronic Music Technology
- ☐ Basic Electronics
- ☐ PC Applications Specialist
- ☐ Programming in C++ with Windows
- ☐ Bookkeeping and Accounting
- ☐ Paralegal
- ☐ Fiction/Nonfiction Writing
- ☐ Building Construction & Remodeling
- ☐ Air Conditioning, Heating, & Refrigeration
- ☐ Electrician
- ☐ Locksmithing
- ☐ Home Inspection
- ☐ Small Engine
- ☐ Automotive Servicing

101-082



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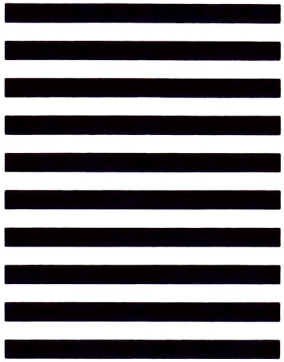

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No other training shows you how to troubleshoot and service computers like NRI!

NEW! 386sx/20 MHz MINI TOWER COMPUTER!
Features 32-bit 80386sx CPU, 1 meg RAM, 64K ROM, 1.2 meg high-density floppy disk drive

MONITOR
High-resolution, nonglare, 12" TTL monochrome monitor with tilt and swivel base

NEW! 40 MEG HARD DISK DRIVE!
You install this 40 meg IDE hard disk drive internally, for greater data storage capacity

DIAGNOSTIC HARDWARE AND SOFTWARE
R.A.C.E.R. plug-in diagnostic card and QuickTech menu-driven software, both from Ultra-X, give you hands-on experience with today's professional

SOFTWARE
Train with MS-DOS, GW-BASIC, and popular Microsoft Works applications software

DISCOVERY LAB
Complete breadboarding system lets you design and modify circuits, diagnose and repair faults

DIGITAL MULTIMETER
Professional test instrument for quick and easy measurements

DIGITAL LOGIC PROBE
Simplifies analyzing digital circuit operation

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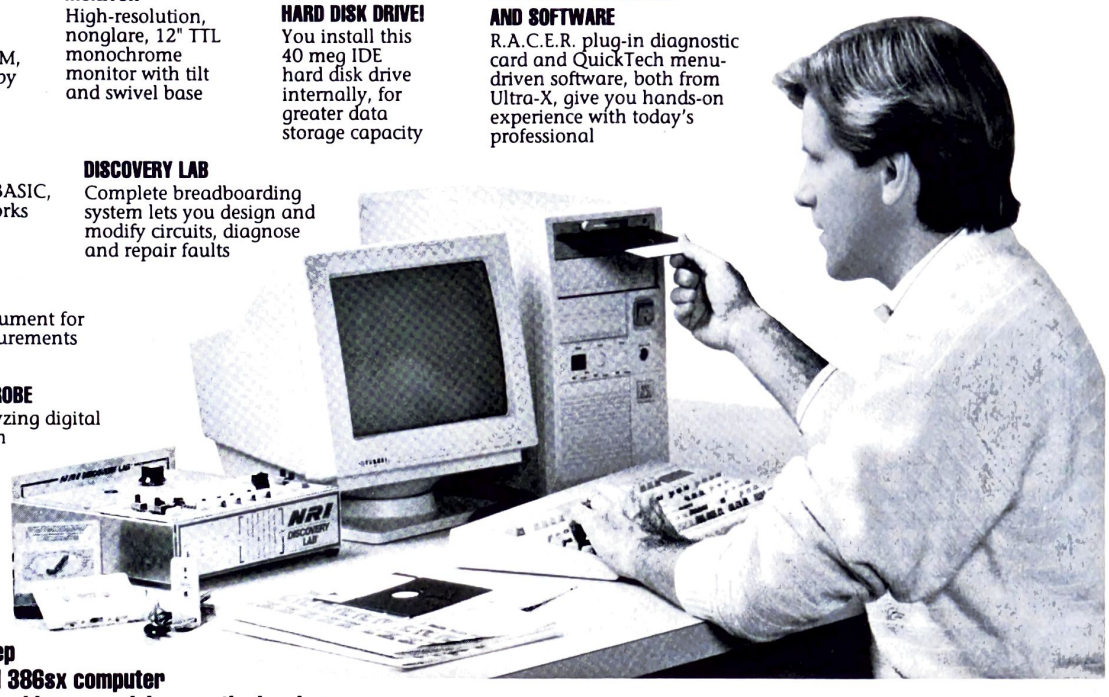

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BIKE TO THE

BY MARCELLE M. SOVIERO

David Schultz and Robert Egger, product designers for Specialized Bicycle Components in Morgan Hill, Calif. and both avid cyclists, have a serious motto: "Innovate or die." The duo's most recent design project is a trio of futuristic bicycles: the FSX mountain bike, the Metropolitan city bike, and the Tandemonium track racer. "We aimed to build bikes that we'd like to ride," says Egger.

The bicycles were created by Specialized's "S-Works" division—the name is inspired by Lockheed Corp.'s famous Skunk Works, which brought to fruition such aviation marvels as the F-117A stealth fighter-bomber. S-Works is composed of a dozen cycling enthusiasts who design their ideal bikes on CAD/CAM computer stations nestled among various types of testing equipment. One machine calculates the strength of a bike by slowly applying more and more pressure to the frame. Another instrument measures the critical geometries of each bike produced and fine-tunes each frame to within a thousandth of an inch. The division is also working on developing an in-house wind tunnel to test new bicycle and wheel designs.

While the bikes are prototypes, the designers say that similar machines could be available for the road within a few years. In the meantime, some of the prototypes' amenities, such as an integrated cycling computer and an advanced suspension system, could show up on several of Specialized Bicycle's mainstream models within a year.

The prototype of the FSX (Future Shock Experimental), designed by Schultz, has a carbon-Kevlar frame that weighs less than 25 pounds. The bike's designer incorporated a suspension that is similar to those found in aircraft landing gear. Air and oil shocks, the air placed in the head tube in front and the oil shock between the swing arm and frame in the rear, provide three inches of travel for jolt-free off-road riding. To ease tire changes, the FSX's wheels are attached to the front blade and rear arm on only one side, so the wheel does not have to be removed.

The FSX also has cable-activated hydraulic disc brakes similar to those used on motorcycles. Disc brakes withstand more heat and friction than conventional cantilever brakes, so they offer improved downhill performance and increased durability.

While conventional bikes use a derailleur and a multitude of gears, the FSX uses a gearbox that fits in the rear hub. The system is basically a continuously variable transmission (CVT) like those used in snowmobiles, or more recently, in small cars ["Finally—CVT," Sept. '87]. The derailleur system, which has been used on bikes since the 1920s, changes gears by moving the chain between smaller and larger gear sets, typically providing 21 gear ratios (for mountain bikes). By contrast, the CVT permits an infinite number of gears with slight continuous changes. The optimum gear is achieved at all times because the CVT responds to changing pedal speeds. "If you pedal best at 80 rpm, you can set that speed with a twist shifter on the handlebar. Your optimum pedal speed will stay the same no matter how fast the bike is going," explains Schultz.

The FSX's most noticeable feature is the seat frame, which allows for a custom fit and also makes the bike easier to manufacture. "There are only two sizes of bike frames for the FSX: small and large. But the seat frame could come in various lengths for shorter and taller riders," says Schultz. The height of the seat is fine-tuned 0.5-inch either

The Metropolitan city bike features a built-in lock for secure parking on city streets.

The Tandemonium track racer for two has a cutaway carbon-composite frame and incorporates twin front wheels and two enclosed drive shafts.

way, with an adjustment knob contained in the frame.

A computer integrated into the handlebars on the FSX provides more information than do current cycling computers. The two-inch liquid-crystal display shows torque and suspension performance. The suspension can be adjusted on-screen by varying the amount of damping. Torque is displayed with bar graphs that indicate the amount of energy being expended. "To switch from one display to another, you just click the handgrips, so you never take your hands off the bars," says Schultz.

The Metropolitan and the Tandemonium were created by Egger. The Metropolitan, with a carbon-composite frame, is designed for urban riders who want to commute in style. "Bicycles are like cars or clothes. They say something about who we are," says Egger. A hybrid of technology and common sense, the Metropolitan contains a built-in cable and lock that is accessible through a sliding panel under the seat. The kickstand, when retracted, folds flush into a space carved out of the rear disc wheel for easy maintenance and a clean look. The brakes are activated by a single lever, so one hand is always free for signaling.

The bicycle's 24-inch wheels make the seat about eight inches closer to the ground than a conventional bike. A lower stand-over height allows for faster and easier mounting or dismounting at crosswalks. The Metro's rear derailleur is controlled by a two-button electronic gear-changer on the handlebar.

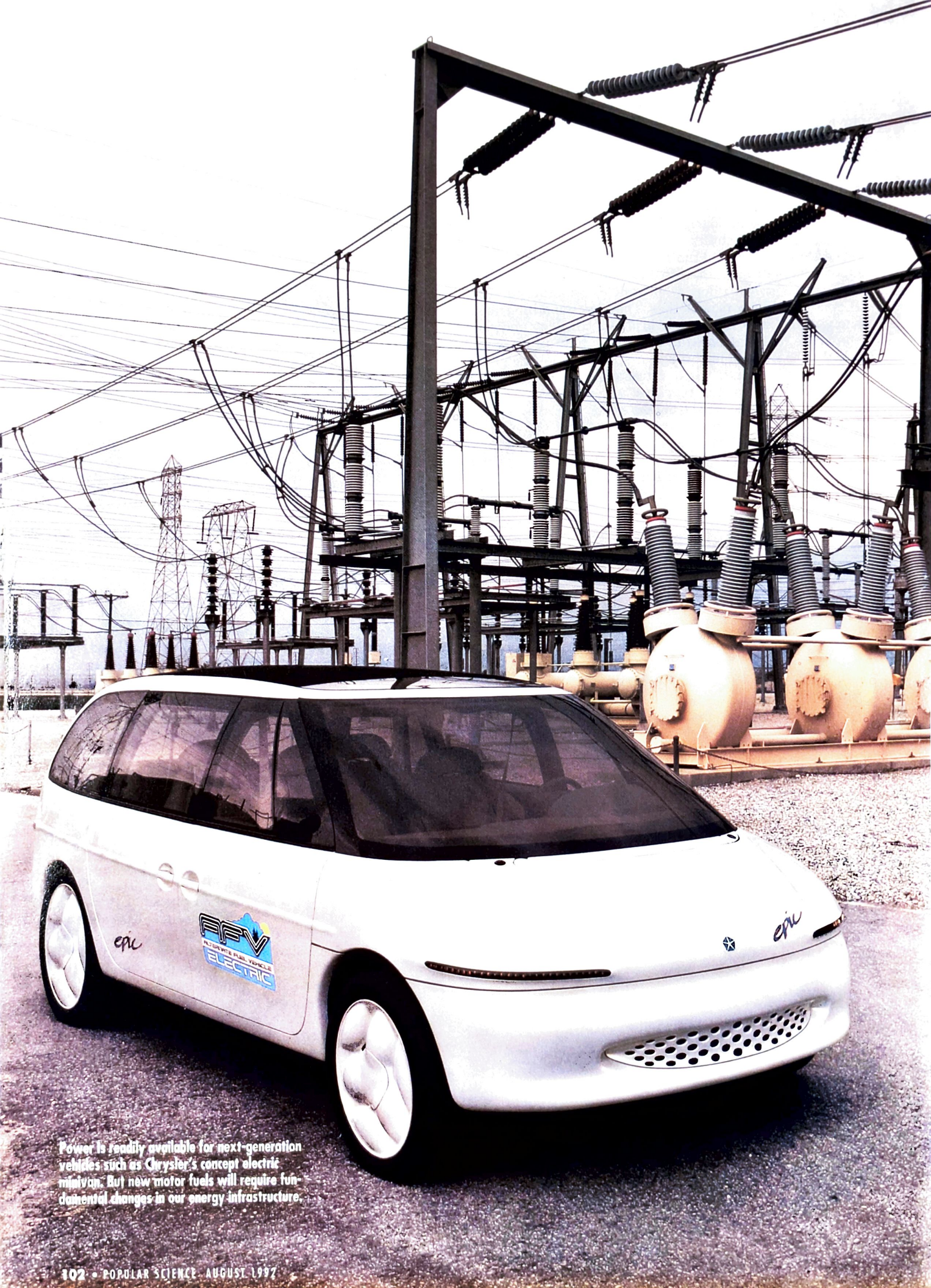
PHOTOS BY MARC GELLER

The FSX (Future Shock Experimental) mountain bike boasts a continuously variable transmission, hydraulic disc brakes, and an advanced suspension system.

The most radical design of the trio is the Tandemonium, a fixed-gear track-racing bike for two riders, that "looks fast just sitting there." In fact, the Tandemonium looks like something that Batman might ride—at one point it was actually considered for the Tim Burton film, but wasn't ready in time.

What's most unusual are the Tandemonium's two 26-inch front wheels, angled at a slight "V," with the fork mechanism tucked between. The twin wheels are on small swing arms so that each one moves independently of the other. This ensures that one wheel is always in contact with the track since the wheels move up and down on banked (angled or curved) tracks, particularly at high speeds. Two enclosed drive shafts—similar to those used in BMW motorcycles—connect the cranksets and rear hub mechanism. Different ratios are achieved by changing bevel gears within the hub, depending on the type of track and speed desired.

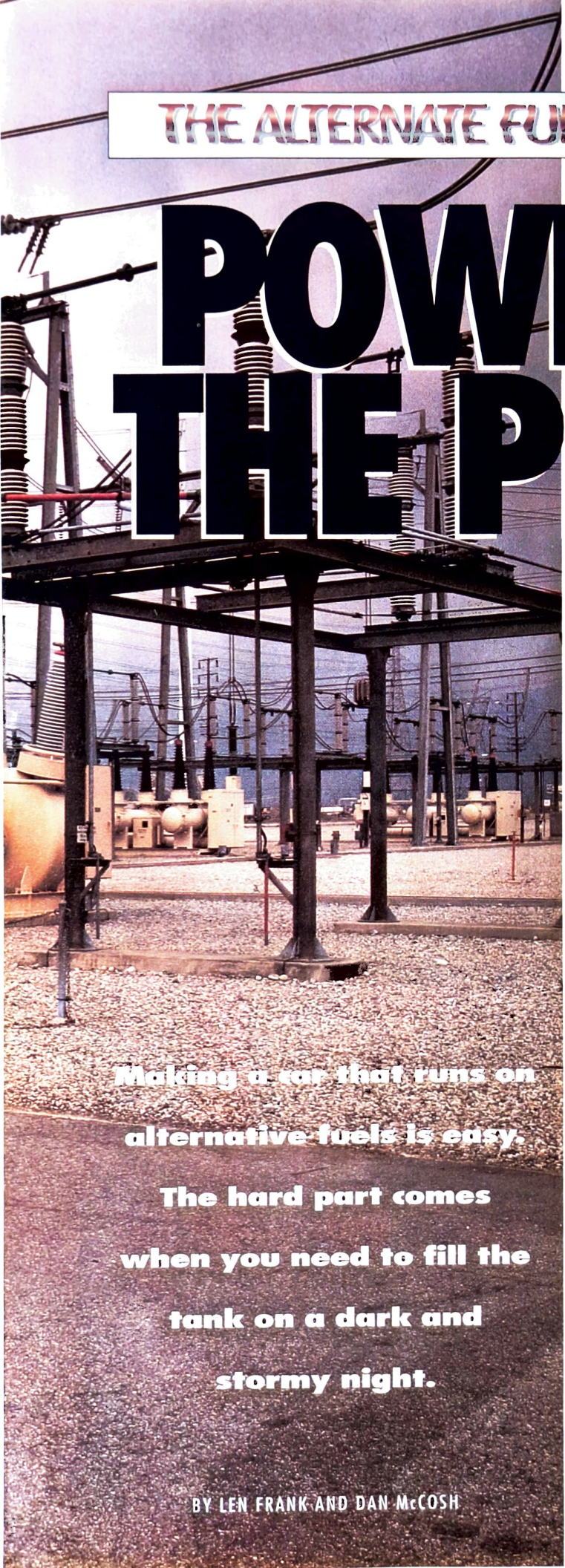
In fact, every aspect of the Tandemonium is aimed toward speed. What's the best way to design an aerodynamic shape? According to Egger, watching fish helps. "There are a lot of 'fishy' parts in the Tandem—no pun intended. Fish go through water, which is much more resistant than air," says Egger. The teardrop shapes incorporated in the frame improve the bike's aerodynamics, and the cutout in the middle of the frame reduces weight and allows air to pass through for stability in high crosswinds. "Speed is everything here," says Egger. "On this bike, you have the advantage of looking really good while going really fast." PS



Power is readily available for next-generation vehicles such as Chrysler's concept electric minivan. But new motor fuels will require fundamental changes in our energy infrastructure.

THE ALTERNATE FUEL FOLLIES • PART 2

POWER TO THE PEOPLE



Making a car that runs on alternative fuels is easy. The hard part comes when you need to fill the tank on a dark and stormy night.

BY LEN FRANK AND DAN McCOSH

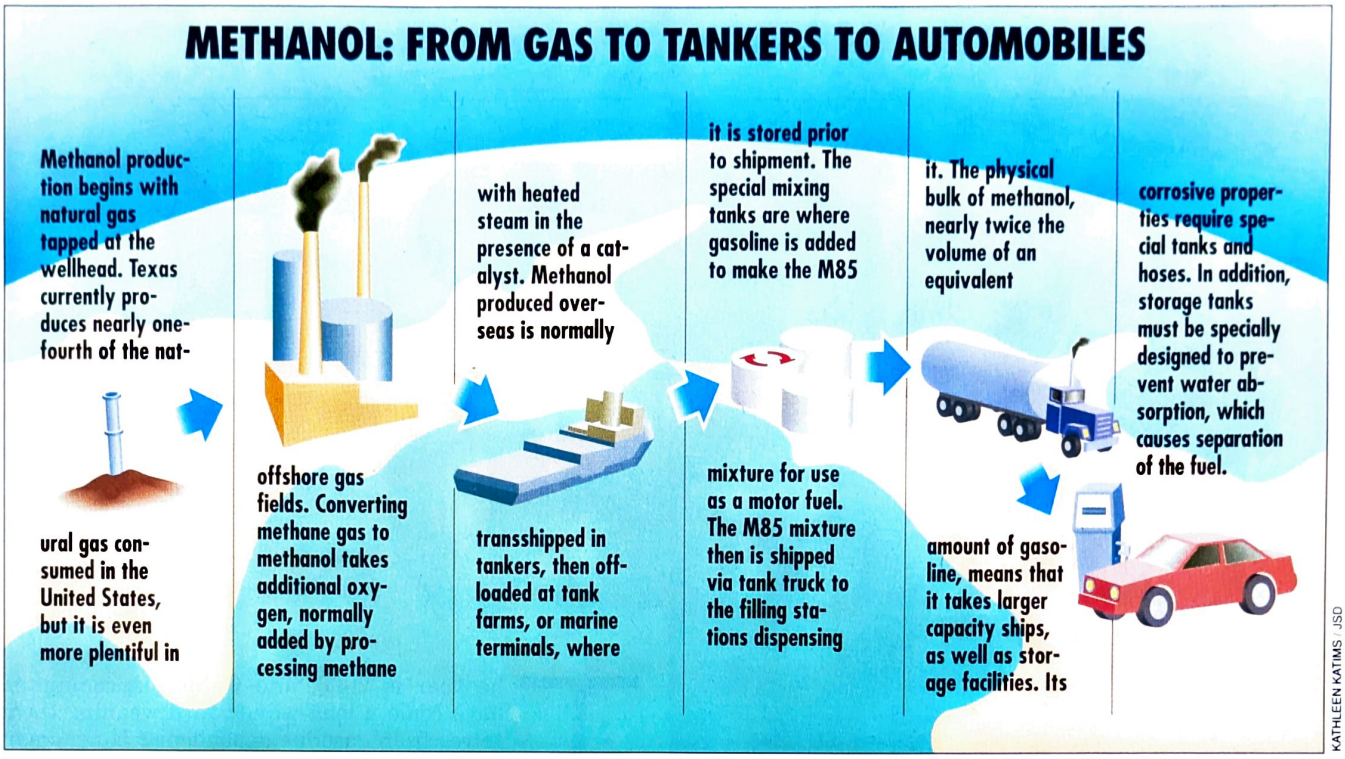
JOHN B. CARNETT

The year is 2006, and California commuters have come a long way toward weaning themselves from gasoline dependency. Huge ocean-going methanol tankers are anchored off San Diego; compressors run in neighborhood garages pressurizing cylinders storing compressed natural gas (CNG); and on a quiet night you can hear the steady buzz of batteries recharging in the distance. A quarter of the cars in California are running on something other than gasoline, still the most popular motor fuel. In fact, the main reason you bought your alternative-fuel commuter car was to get past the checkpoints into the clean-air zone at the center of town. Still, it can be tough to see Los Angeles, and sometimes you wonder if things have improved all that much, if the smog will ever actually go away.

In 1992, smog piles up along the mountains that surround Los Angeles, trapped from above by the inversion layer—cool dense air from the ocean that acts like a lid on a witch's caldron. It has no place to go but east, where it builds up in Riverside until that basin is full, then begins to spill over more mountains into the desert toward Palm Springs. It's an old problem for the Los Angeles basin. In 1968, Riverside County, in desperation, sued neighboring Los Angeles County for polluting its air.

Considerable progress has been made in the past two decades. There has been a 25 percent reduction in ozone (O_3) in the last 12 years, despite a doubling of the vehicle-miles driven and a state population that has grown some 50 percent. Much of this is credited to modern-day emissions controls on passenger cars that have already eliminated 96 percent of hydrocarbons (HC) and 76 percent of oxides of nitrogen (NO_x) in the exhaust stream compared with cars produced in the late 1960s. California has the strictest auto emissions standards in the nation and is a model for other states with dense urban populations and smog problems. Now California is embarking on a radical new program aimed at improving air quality: forcing auto makers to produce cars powered by alternative fuels that promise to further reduce smog-producing exhaust emissions, or even eliminate exhaust altogether.

But introducing new fuels into a system currently limited to gasoline and diesel fuel, with a smattering of propane, is far more difficult than simply re-engineering engines to run cleaner. Alternative fuels have been tried in California and are being tested in other states, and it's quickly becom-


METHANOL: FROM GAS TO TANKERS TO AUTOMOBILES
Methanol production begins with natural gas tapped at the wellhead. Texas currently produces nearly one-fourth of the natural gas consumed in the United States, but it is even more plentiful in offshore gas fields. Converting methane gas to methanol takes additional oxygen, normally added by processing methane with heated steam in the presence of a catalyst. Methanol produced overseas is normally transshipped in tankers, then offloaded at tank farms, or marine terminals, where it is stored prior to shipment. The special mixing tanks are where gasoline is added to make the M85 mixture for use as a motor fuel. The M85 mixture then is shipped via tank truck to the filling stations dispensing it. The physical bulk of methanol, nearly twice the volume of an equivalent amount of gasoline, means that it takes larger capacity ships, as well as storage facilities. Its corrosive properties require special tanks and hoses. In addition, storage tanks must be specially designed to prevent water absorption, which causes separation of the fuel.
KATHLEEN KATIMS/JSD

ing apparent that the new motor fuels will mean fundamentally altering the way we produce and distribute energy.

This should be a simple story—the issues seem so clear-cut: The use of gasoline in internal combustion engines causes air pollution, photochemical smog, increases the greenhouse effect, punches holes in the ozone layer, and will bring mankind to its collective knees. And besides, we're running out of oil.

The solutions presented thus far seem equally clear: Cut back on the use of oil until we can stop using it altogether and, until the magic-bullet batteries are found, burn clean fuels like natural gas, propane, ethanol, methanol, and hydrogen. But under closer scrutiny, the issues become murky.

Amendments to the federal Clean Air Act of 1990 already call for an additional 50 percent improvement by 1994 in emissions standards for new gasoline-burning cars and set HC standards to a scant 1 percent of pre-legislation levels.

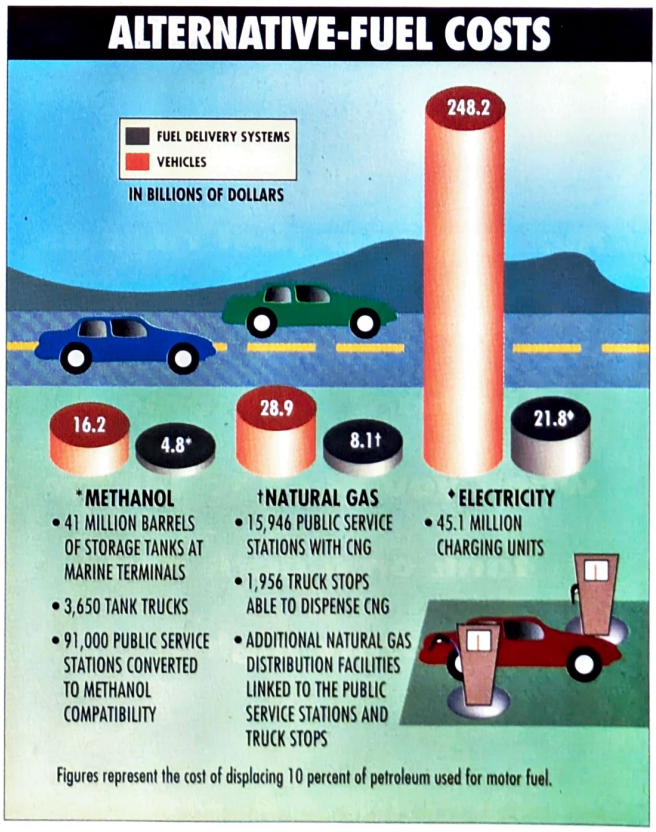
California's Air Resources Board (CARB) goes even further. CARB's latest emissions standards present a timetable that starts in 1996, and by 2003 calls for 15 percent of all new vehicles sold to be so-called ultralow-emissions vehicles, likely burning alternative fuels, and another 10 percent to be zero-emissions vehicles, which means electric cars. So far, about 15 states have voted to adopt the California standards, making a broad-based shift to alternative fuels seem inevitable. Auto companies already are producing a handful of cars that run on alternative fuels ["The Alternate-Fuel Follies," July], and electric cars are expected to be on the road in a few years. But getting a genuine alternative-fuel infrastructure in place could take a lot longer.

The U.S. Department of Energy (DOE) has been studying alternatives to crude oil as far back as the energy crisis of the mid-1970s—long before the current concern about ultralow emissions standards. The most attractive fuels —methanol and compressed natural gas—are genuine alternatives mainly because they are in plentiful supply. Methanol is now produced in abundance primarily from natural gas, or methane, after the flurry of worldwide oil exploration sparked by two oil embargoes.

The California methanol program started in 1979, after the second gasoline shortage. By 1986, California had a test fleet of methanol-powered vehicles that had logged 12 million miles of service.

Methanol's chief advantages, aside from the convenience of a liquid fuel, are slightly improved performance compared with gasoline and increased range compared with CNG, due to the difficulty of storing CNG in cylinders. A car originally designed to be powered by methanol could be lighter, from savings in the size and weight of the cooling system, and could have slightly more power.

A mixture of 15 percent gasoline, 85 percent methanol —called M85—will corrode or dissolve many normal fuel-sys-


ALTERNATIVE-FUEL COSTS
FUEL DELIVERY SYSTEMS
VEHICLES
IN BILLIONS OF DOLLARS
248.2
16.2
4.8*
28.9
8.1†
21.8*
*METHANOL
• 41 MILLION BARRELS OF STORAGE TANKS AT MARINE TERMINALS
• 3,650 TANK TRUCKS
• 91,000 PUBLIC SERVICE STATIONS CONVERTED TO METHANOL COMPATIBILITY
†NATURAL GAS
• 15,946 PUBLIC SERVICE STATIONS WITH CNG
• 1,956 TRUCK STOPS ABLE TO DISPENSE CNG
• ADDITIONAL NATURAL GAS DISTRIBUTION FACILITIES LINKED TO THE PUBLIC SERVICE STATIONS AND TRUCK STOPS
*ELECTRICITY
• 45.1 MILLION CHARGING UNITS
Figures represent the cost of displacing 10 percent of petroleum used for motor fuel.
SOURCE: U.S. DEPARTMENT OF ENERGY
JOSEPH ULATOWSKI

tem materials, however. M85 has less energy content per gallon than gasoline, which cuts range with the same size tank to slightly more than half that of a gasoline car (about 1.6 gallons of M85 to one gallon of gasoline).

Exhaust emissions from M85 are claimed to be less reactive—that is, less likely to form photochemical smog. About 75 percent of the hydrocarbons formed when it burns have low reactivity. In contrast, exhaust from gasoline cars is about 75 percent moderately reactive. M85, however, has double the highly reactive emissions compared with gasoline (10 percent versus 5 percent). Further, an M85-powered vehicle with any tuning problem (a bad spark plug wire, bad dioxide (O_2) sensor, for example) will have vastly increased production of carcinogenic aldehydes.

A DOE report on the cost versus benefits of alternative fuels assumes that most methanol consumed as a motor fuel will be produced overseas, where natural gas is virtually free and huge methanol production plants are already built. It can be shipped, stored, and distributed more or less like gasoline, but the sheer increase in bulk due to the lost energy content per gallon translates into some impressive numbers. Storage tank farms would have to double in size and be specially constructed to eliminate water contamination. Likewise, the number of tank trucks on the road would dramatically increase. Methanol can be handled in gas stations, but the chemical properties attack some hoses and even dissolve some fiberglass underground tanks —which would have to be doubled in size in any case.

To distribute enough methanol to displace about 10 percent of the petroleum now consumed in the United States would take some heavy new construction. The DOE lists 116 new marine terminals for unloading tankers, 91,000 new service stations equipped (or re-equipped) to dispense methanol, and about 1,500 new tank trucks added to the existing fleet —about 50 percent more trucks on the road. Some $16.2 billion of the estimated $21 billion for a full-blown methanol program is the cost of the methanol-burning vehicles themselves—which presumably would be paid for by consumers as a premium when they buy the flexible-fuel cars.

Yet with all its drawbacks, methanol remains one of the easiest fuels to adapt to today's fuel distribution system. Vehicles can be switched from methanol to gasoline simply by putting it in the tank. Methanol forms a kind of chemical null point at the intersection of many different potential feedstocks: It can by synthesized from natural gas, coal, or even wood. (The DOE has actually studied the potential of converting trees to methanol, at about $1.25 per gallon.)

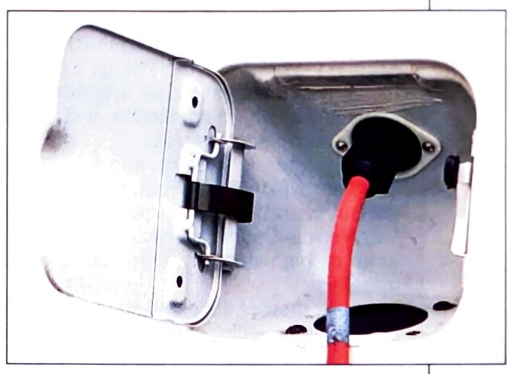
Natural gas, the other leading alternative fuel, likewise has several potential sources, including recovery from decomposing dumps. But most of it is recovered from fossil gas trapped underground. It is already widely distributed in the United States, and the DOE estimates no new reserves or storage systems would be needed, even to supply enough to account for the same 10 percent petroleum substitution.

Currently more than 750,000 vehicles worldwide use CNG, many in plants and warehouses. CNG is low in tailpipe emissions, but the picture is confused by "nonreactive hydrocarbons," which are counted differently than those with greater volatility. Methane gas is a greenhouse gas, as is carbon dioxide. Presumably, methane helps the smog problem but contributes to global warming. According to one emissions engineer, the cleanest running nonelectric production vehicle available today is the dedicated CNG-fueled full-size Dodge van.

The downside of CNG is lack of range. Fueled at about 3,500 pounds per square inch (psi), a full-size car has a range of only about 100 cruising miles, which translates into a need for significantly more fueling stations. Higher pressures for quicker fill-ups require far more energy to compress. Refueling stations must raise the pressure to the required 3,500 psi for fast fill, about five minutes. Slow fill, requiring about eight hours, is more efficient because it heats the gas less and cooler CNG is denser. CNG engines require less maintenance than gasoline- or alcohol-fueled engines.

The compressors are the major cost of a CNG infrastructure, according to the DOE. A typical service station capable of quickly refueling passenger cars costs more than $300,000 to build, and a truck stop with special pipelines and heavy compressors could exceed $1 million (there are about 2,000 truck stops in the United States). Most CNG fueling stations are currently in local gas companies or fleet garages. Filling nozzles are not yet as standardized as those for gasoline, but are not much more difficult to use. Some oil companies have

PLUGGING INTO THE ELECTRICAL GRID



Recharging an electric car takes from three to six hours, depending on household current.

Electricity already is delivered to virtually every building in the country by a vast network of cables and wires. Therefore, the infrastructure to accommodate large numbers of electric cars is in place right now. Or is it?

Most electric utility companies see vehicles with batteries instead of fuel tanks as a way to keep their expensive generating equipment running—and making money—during hours of low consumption. "There's a deep trough in demand from midnight to 4 a.m. just about everywhere in the country," says Jim Janasik, transportation program manager at the Electric Power Research Institute in Palo Alto, Calif. "At night, 10 million to 20 million electric cars could be supported without adding capacity."

The time required to recharge the vehicles is a major issue. Ideally, electric-car owners would plug into 220-volt, 30-ampere outlets, recharging a vehicle in three to six hours, compared with overnight at 110 volts. Two-way "smart" electric meters may also be developed that will communicate with the power company through telephone lines, signaling the charge state of the vehicle's battery. Discounted "interruptible" power would be intermittently supplied at night—with a guarantee that the car would be road-ready in the morning.

"Zero-emissions vehicle" is a misleading term; emissions-displacing vehicle would be more honest. The remote power plants generating the current for vehicle batteries inevitably have an impact on the environment. The nature and scale of this effect, however, can be difficult to assess. Southern California Edison Corp., for example, uses no less than nine energy sources: nuclear, natural gas, coal, hydroelectric, solar, wind, biomass, and geothermal.

Mark A. Deluchi, a researcher at the Institute of Transportation Studies at the University of California at Davis, has studied projected per-mile emissions of electric vehicles with those of gasoline-fueled vehicles in the year 2010 that includes the power source for recharging batteries. The electric fleet yields dramatic reductions only in unburned hydrocarbons (HC) and carbon monoxide (CO). Other key emissions vary widely from better to worse, depending on the fuel burned (natural gas or coal), emissions controls at the power plant, and the type of generating equipment.

Still, the numbers show startling reductions in HC and CO—two of the three primary pollutants now controlled in cars. Deluchi's projections argue strongly in favor of adopting electric vehicles in cities with local air-quality woes.—*Stuart F. Brown*

HOW TEXAS IS SWITCHING TO CNG

Located just north of downtown Austin, Texas, in a former auto dealership, the Natural Gas Vehicle Technology Center is the country's largest facility providing one-stop-conversion, maintenance, and refueling of natural-gas vehicles.

The center is a joint effort between Southern Union EconoFuel, part of the local Southern Union gas utility, and Natural Gas Vehicle Development Co., a manufacturer of high-strength aluminum storage cylinders.

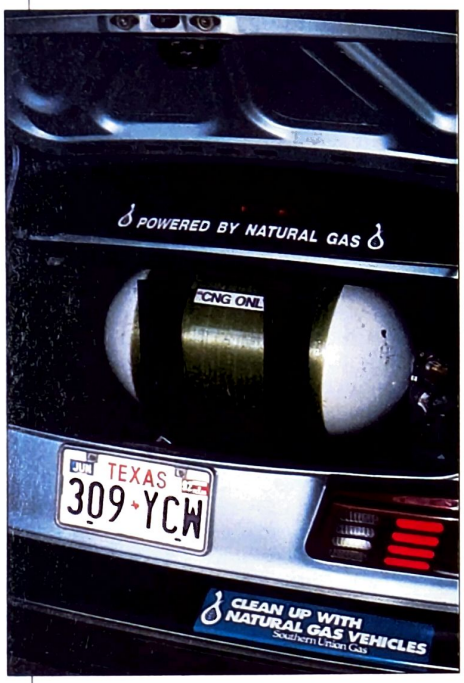
Initially, most of the conversions will probably be fleet vehicles. "We expect to convert 1,000 vehicles to compressed natural gas (CNG) during the first year the center is open," says Southern Union president Peter H. Kelley. "By the third year, our target is 3,000 vehicles annually."

CNG has long been the primary alternative fuel choice in Texas, a state that sits atop one-quarter of the nation's proven natural gas reserves. Texas's Clean Air Act stipulates that as of September 1994, 30 percent of certain commercial fleets must use alternative fuels such as CNG. That figure increases to 50 percent by September 1996, and 90 percent by 1998.

The center stocks CNG conversion kits for most fleet vehicles. Installation usually includes a fill valve, storage cylinders, master manual shutoff, stainless steel fuel lines, pressure reducing regulators, and a solenoid valve to control flow to the engine. Most vehicles retain gasoline capability, so a selector switch is installed that allows easy shifting between gasoline and CNG. Installation takes from two to three days.

Drivers considering converting their vehicles to CNG receive an analysis of the cost and expected savings from CNG. For example, a 20-vehicle fleet that is converted to CNG that averages 15 mpg and 15,000 miles per year can save a company $12,800 annually in fuel and maintenance costs. The payback period for a conversion cost of $2,800 to $3,500 per vehicle ranges from 48 to 65 months.

The center also offers repair facilities, training for drivers and fleet maintenance personnel, and an on-site public service station with CNG pumps that resemble traditional gasoline pumps and fuel a standard-size car in about the same amount of time. The center's filling station is one of eight scheduled to open in Austin by the end of the year. Another four are planned for El Paso.—*Richard Marini*



A CNG conversion fits the tank in the trunk and retains the ability to run on gasoline.

installed CNG stations along with their gasoline pumps.

Other alternative fuels less favored than methanol or CNG are still under scrutiny:

Ethanol (ethyl alcohol or grain alcohol) is as familiar as your favorite beer. Ethanol was used as a motor fuel as long ago as any petroleum distillate—the 1870s at least. Considerably more benign than M85, E85 (15 percent gasoline, 85 percent ethanol) otherwise has similar characteristics. Brazil launched an ambitious ethanol fuel program in the mid-1970s, and major car manufacturers, such as Ford, Volkswagen, and General Motors, have produced millions of ethanol-burning vehicles for that market.

Because ethanol is generally distilled from crops, the "30 percent to 50 percent lower emissions" claim made for ethanol (the same as that made for methanol) must be tempered with the knowledge that the growing, fertilizing, harvesting, drying, and transporting of those crops produces considerable carbon monoxide (CO), carbon dioxide (CO_2), and even some nitrogen compounds—the EPA estimates six times as much as producing and burning a gallon of gasoline. Burning ethanol, however, does not produce dangerous aldehydes.

Liquefied petroleum gas (LPG or propane) has been used as a vehicle fuel since 1913. More than 3.5 million propane-powered vehicles are running worldwide, 350,000 in the United States. There are 10,000 propane refueling sources in this country—more infrastructure for the transportation and distribution of LPG than for any other alternative fuel.

Hydrogen as a vehicle fuel is a wild card. Every other fuel available today has big business behind it, with concurrent lobbying pressures and with, or without, government proponents pushing for its use. In the United States, though, only the American Hydrogen Association (AHA), well-intentioned enthusiasts, supports hydrogen.

There is, of course, a limitless supply of hydrogen—if it can be separated from water economically. Separating the "hydrogen" from its companion "O" requires large amounts of electricity—and the logical source of that is solar power, says Roy McAlister, president of the AHA and professor of thermodynamics at Arizona State University. McAlister says that the Saudis are engaged in a program to do just that—derive hydrogen from seawater using solar power. He says the Saudis plan to produce 25 percent of the world's energy requirements from hydrogen.

McAlister points out that it's possible to remove hydrogen from methane and have fuel left over. Carbon derived as a byproduct of hydrogen production may eventually become more important than the hydrogen itself as we learn to use structural carbon more effectively.

Fascinating stuff, but currently there is no mass production of hydrogen for fuel anywhere in the world. Hydrogen is composed of large, active, "loose" molecules and its Btu content is not high (liquid hydrogen has about one-fourth the Btu of gasoline but weighs far less); consequently, adequate hydrogen storage is difficult. Hydrogen's burn rate is very high—it is difficult to keep from exploding (detonating), though a rich mixture or water injection helps.

DOE projections reveal the magnitude of converting a significant number of the nation's vehicles to alternative fuels. The scenarios for each type of fuel vary, but according to the DOE it would take between 30 and 40 million alternative-fuel vehicles on the road to displace the fuel consumption of 10 percent of the current petroleum-powered fleet nationwide. It would take about ten years of steady production, starting in 2006, to sell that many cars and trucks—assuming the full number mandated by the CARB scenario is actually built and sold.

Unfortunately, the net gain in air quality that comes from substituting alternative fuels in internal-combustion engines is much less than the savings in gasoline. Only half the smog in the United States is blamed on the nation's vehicles to begin with. The improvement anticipated with the "clean" fuels could make them about twice as clean as gasoline. But with just 15 percent of these cars and trucks burning "clean" fuel, the best case for overall improvement is only about 7 percent of the total smog-producing emissions from mobile sources—a meager 3.5 percent reduction overall. Zero-emissions electric cars, if they eventually reached

[*Continued on page 114*]

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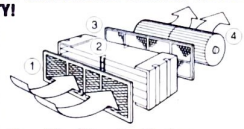

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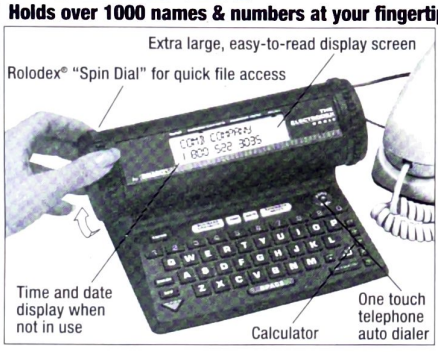
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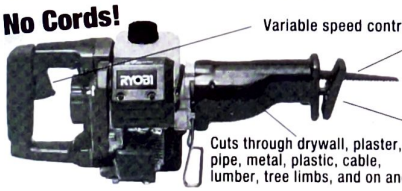
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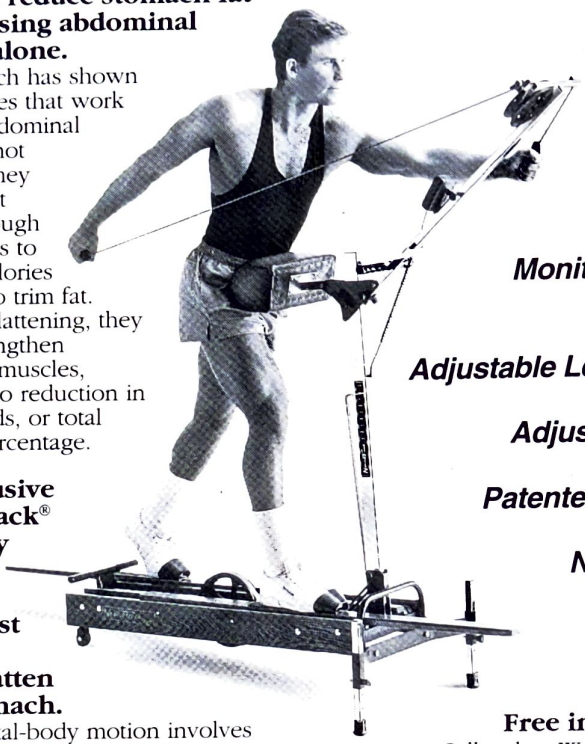

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Science and math

[*Continued from page 63*]

fewer than one in four boys and one in ten girls still choose such a career.

Frank H. T. Rhodes, president of Cornell University and a member of the National Science Board, writes that "if current trends continue, the nation may face a cumulative shortfall of 700,000 technically trained individuals, including 400,000 with a bachelor's of science degree, by the first decade of the 21st century. At the doctorate level, the shortage could reach 9,600 per year. Shortages of this magnitude would be a crippling national handicap. Even if we still have the geniuses to devise the most creative research investigations in science and engineering, we may not have enough well-trained 'foot soldiers' to put ideas into productive practice as they carry out the work of science and technology day by day.

"We will meet President Bush's goal of being first in science and mathematics achievement by the end of the century or we will remain at or near the bottom of the international heap, in which case our society will find it difficult to match the achievements of the more highly educated and technically skilled communities in the world."

Is it really possible to meet that goal? Of course not. The twelfth-grade class of 2000 has completed fourth grade and is already falling far behind.

"That's an immense order," says Betty Vetter. "U.S. students are now last instead of first in all of the international competitions we have entered in the last decade, most recently in 1991. And it is not just in contemporary international comparisons that we fall short, but also in comparison with what earlier American students knew at the same age."

Even Colorado Gov. Roy Romer, chairman of the National Governors' Association panel that generated the six America 2000 resolutions, is skeptical, saying, "Some of these goals certainly are grandiose . . . . The math and science goal in particular is probably unreachable."

If not the year 2000, then when? To make any kind of headway, we must determine what landed us in this science/math pickle in the first place and then implement practices and policies that will pull us out of it. PS

The second article in this three-part series will examine the ingredients of the science/math education predicament, from a hodgepodge of school curricula to societal breakdown, and detail proposed solutions.

ANSWERS: 1-B; 2-D; 3-C; 4-E

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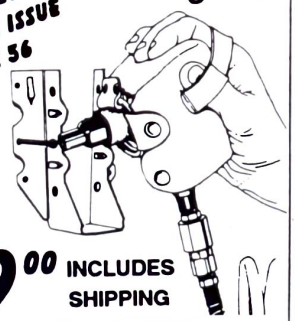

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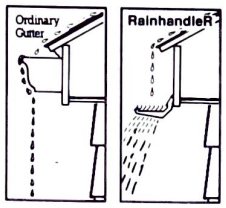

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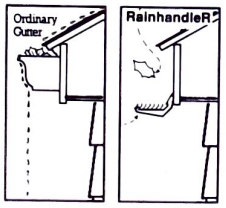

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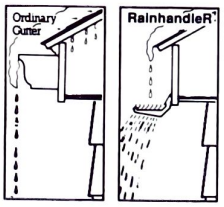

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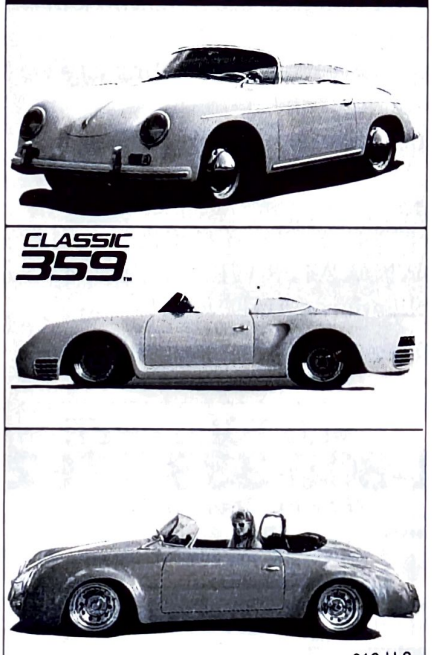

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Hanford

[*Continued from page 57*]

Wash., near Hanford, received as much as 1,175 rems of iodine, or nearly ten times the Chernobyl dose, but over a longer period of time. Unlike the Chernobyl catastrophe, there were no immediate deaths. But the Pasco children are now middle-aged, and they're beginning to wonder if the 15-to-25-year gestation period of some radiation-induced cancers is finally coming due.

While it's difficult to directly connect cancer deaths and serious disease with these emissions, preliminary evidence pointing a guilty finger at sites like Hanford has rapidly accumulated. The amount of illnesses among people who lived near Hanford or outlying areas has been alarming enough to prompt several research studies. And there are on-going investigations at the DOE's other nuclear waste sites as well. A brain cancer study has begun in New Mexico to determine whether the high incidence of the disease found in a cluster near Los Alamos was somehow connected to radiation releases from the laboratory.

Studies under way

Three major "dose effects" projects are expected to determine the levels of early radiation exposure received by families who lived near Hanford and military personnel who worked at the nuclear reservation. These dose-effects studies will try to determine just how much radiation people were exposed to during the peak periods of bomb production and whether their health will show the effects.

One, a four-year-long study, expected to be finished soon, involves only Hanford military veterans and their exposure to low levels of radiation during the years 1943 to 1962. A companion four-year study that won't be completed for two or three years is targeting civilians who lived in the surrounding towns. This study has a steering panel made up of government officials, private individuals, and representatives of contractors.

The third dose-reconstruction project (partly funded by the Three Mile Island Public Health Fund) is headed by the widely known but controversial British epidemiologist, Dr. Alice Stewart, who first brought to light the dangers of exposure to low levels of radiation in the early 1970s. She has fought, among other abuses, the practice of keeping records and documents secret that could have a bearing on worker health. Initially, Stewart and her colleagues' work was vilified, but in recent years the public and government officials have taken her research

seriously. Dr. Ethel Gilbert, a biostatistician with Battelle Pacific Northwest Laboratories, has refuted Stewart's findings, claiming the British doctor's viewpoint isn't shared by the majority of experts who are still awaiting evidence of low-level radioactive doses. But Stewart says that her new study will merely confirm what the data has shown for some time: Even low levels of radiation exposure over long periods cause increased incidence of cancer.

Yet another Hanford study, which won't be completed until 1994 or 1995, is under the auspices of the federal Centers for Disease Control. It's hoped that it will reveal the level of radiation exposure received by people with thyroid cancers. Just how much the iodine fallout (known to concentrate in the thyroid) affected their health will be up to the courts to determine. Currently, a massive class-action suit (there are some 800 plaintiffs) is pending against several government contractors in Federal District Court in eastern Washington. It will take years to assign the blame, however. Some authorities expect that if culpability is proved, it will prompt hundreds of personal-injury suits. Dr. Scott Davis, the epidemiologist working on the thyroid study, says, "Nobody has done anything quite like this. There have been lots of studies of radiation, but we're trying to go back 45 years and do a cohort study. We're trying to locate the people who were exposed."

One reason these research studies are so long and arduous is that it's a daunting, if not an impossible, task to find those military personnel and their families who first worked and lived at Hanford. Another is the lack of available data, even when these people resurface in far-flung locations. "From the beginning, none of the enlisted men had radiation badges, and most of the officers didn't have them either," says Wally Cummins, research director for the military personnel study. "To me, that was an incredible oversight. A bunch of 35-cent dosimeters could have saved millions of dollars in research monies." Perhaps, too, many incidences of radiation-induced disease.

More surprises?

Will there be more startling disclosures of radiation leaks and discharges? It's certainly possible, at Hanford and at other sites. We are just getting to the truth many years later, thanks to a raft of documents —more than 40,000 pages—released by the DOE under the Freedom of

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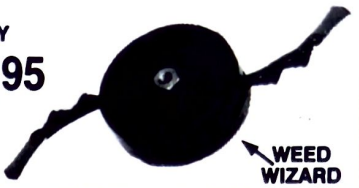

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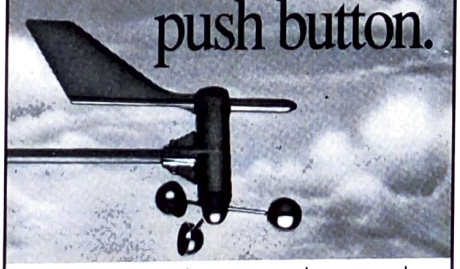

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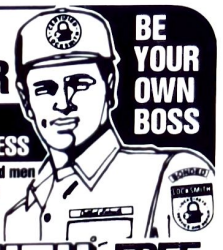

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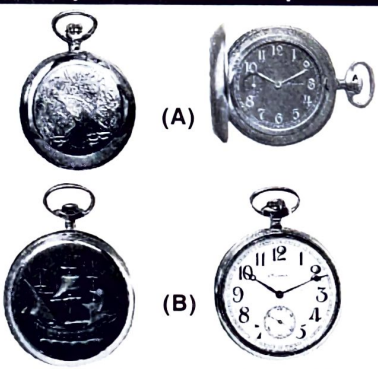

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Hanford

[*Continued from page 111*]

Information Act. More files currently under review (to see to it that nuclear secrets aren't divulged) are scheduled for public disclosure. "There are literally tens of thousands of boxes that nobody has looked through," says Joe Stohr, chief of staff for the Technical Steering Panel of the Hanford Environmental Dose Reconstruction Project. And, adds panel member Norma Jean Germond, not given to overstatement, "I'm never surprised when more surprises come out of Hanford."

That radionuclides have crept into the Columbia River, which passes through the northern part of Hanford and wends its way along the eastern boundary of the reservation, is not disputed. What's still debated is whether they're harmful. Many people, most of whom were—or still are—ardent supporters of the nation's nuclear weapons program, are beginning to wonder if there's a link with serious illnesses and the radiation leaks and emissions from Hanford that have found their way into the air, soil, and water. Environmental groups insist that there are. Westinghouse believes safe levels haven't been exceeded. Meanwhile, as experts make their case, each day some 1.5 million gallons of radioactive water from research labs are dumped into Hanford's trenches. Whether it will leach into the groundwater before the radiation dissipates, nobody yet knows. Dangerous radionuclides have wide-ranging half-lives, and some travel faster than others.

Learning curve

Norman Buske, a physicist who has worked for Greenpeace and other environmental activist groups, fears the problems are worse than officials admit. He's made several experiments on behalf of environmental groups near the Columbia—which irrigates thousands of acres of farmland—that resulted in disconcerting news. On one occasion, a springwater sample drawn from the shoreline near a closed reactor contained nearly twice the amount of beta radiation allowed by the EPA for drinking. Another time, he discovered high amounts of strontium-90 and cesium-137 in the mulberry bushes and other plants along the shore. "One salad," Buske says facetiously, "would meet your annual safe dose of strontium."

As scientists learn more about disposal techniques, they're learning to ask, "What's the true risk to the public and the environment?" says Westinghouse's Ron Bliss. It's something that must be measured every day. PS

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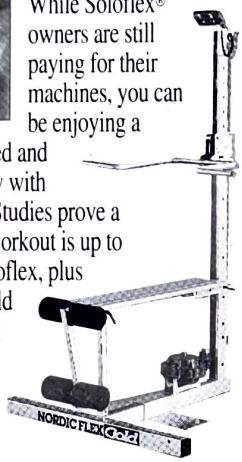

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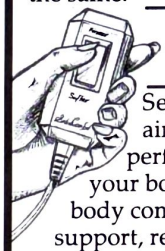

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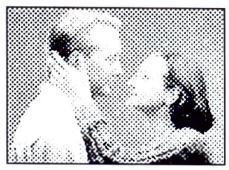

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[*Continued from page 106*]

the anticipated 10 percent goal of the vehicle fleet, would have a much higher impact on air quality. But clearly, improvements in emissions control of the much larger fleet of conventional gasoline cars will be even more meaningful, particularly the new mandate that cars must meet emissions standards for 100,000 miles, rather than the current 50,000 miles.

Why then use alternative fuels at all?

The California Energy Commission has worked out a program to encourage the use of M85 that involves subsidizing fuels and vehicles as well as tacit penalties for nonparticipation. Many states are simply demanding that larger fleets, including their own, burn alternative fuels.

Auto manufacturers could get significant relief from federal average fuel economy standards under a proposal to compute only the gasoline burned in an M85 mixture to determine fuel economy. This would mean that to meet fleet-average fuel economy standards, methanol-burning cars could be calculated as getting 100 mpg or more —which means that more gas-guzzlers could be produced. Another proposal allows heavy industry to get "emissions credits" against smokestack pollution by using a fleet of alternative-fuel cars. Obviously, both these proposals would tend to nullify any real gains in the atmosphere.

Is gasoline best?

A few points to remember: Burning any of the fuels, fossil or renewable, produces oxides of nitrogen—this includes burning fuels to produce electricity. Burning any of them except hydrogen produces carbon dioxide—increasingly thought to be a contributor to the greenhouse effect and the formation of ozone. At this point it becomes a matter of pessimism versus optimism—which side do you believe?

According to an engineer who studies emissions for a major manufacturer, the best alternative to gasoline is probably no alternative at all—it's gasoline.

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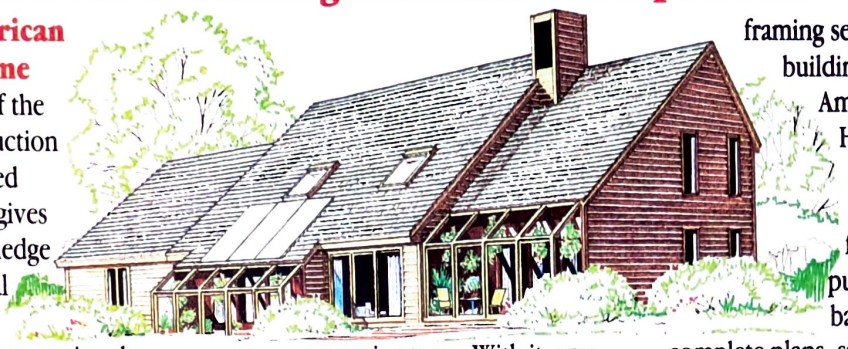

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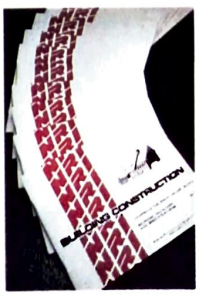

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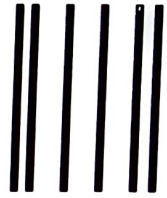

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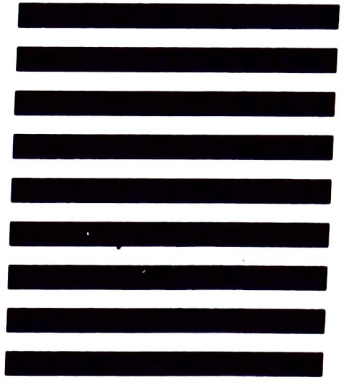

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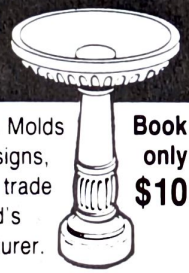

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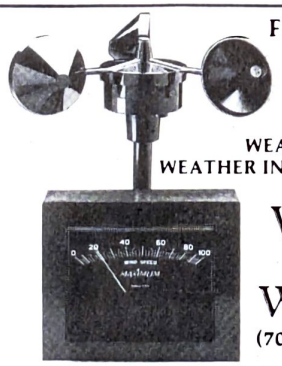

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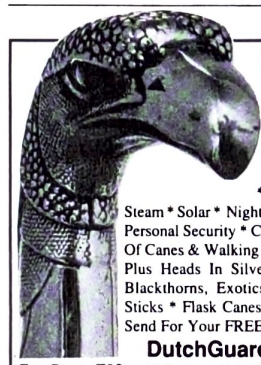

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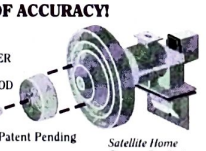

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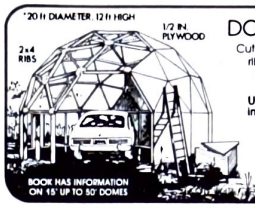

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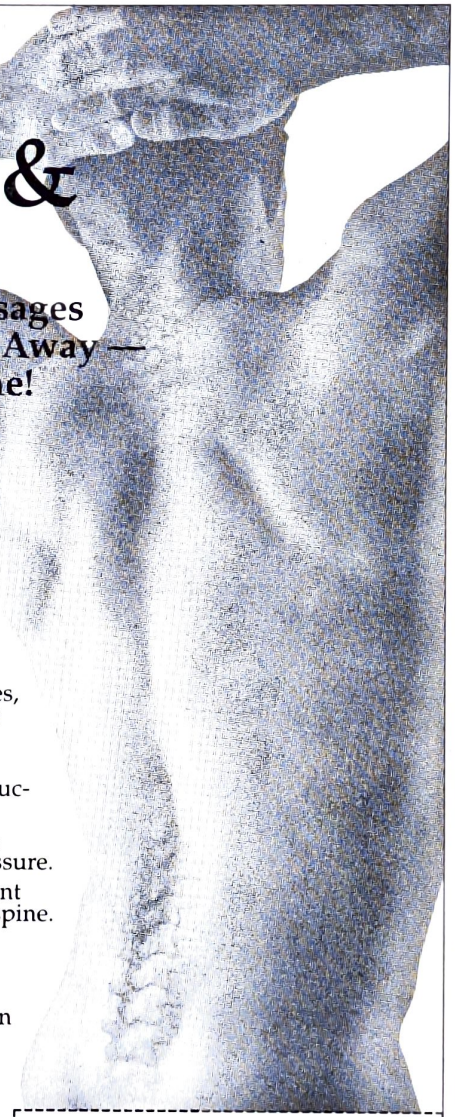

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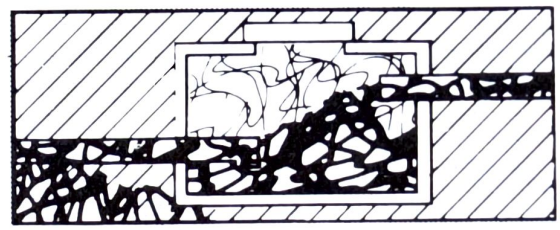

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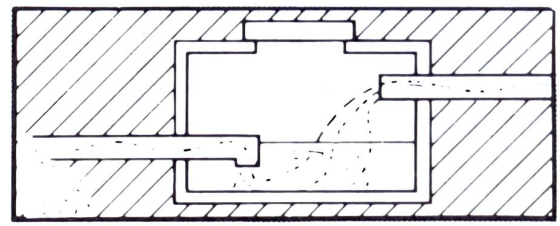

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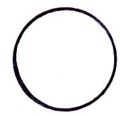

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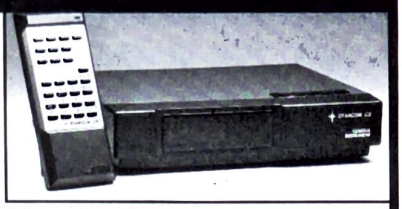

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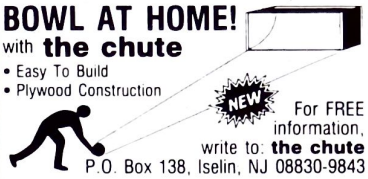

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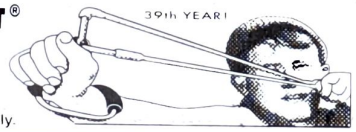

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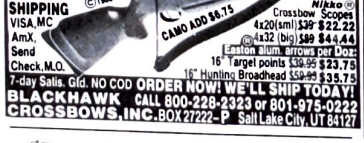

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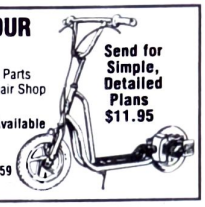
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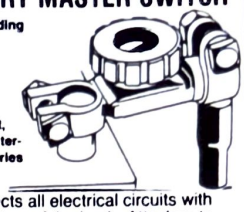

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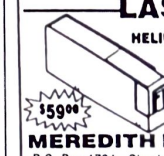

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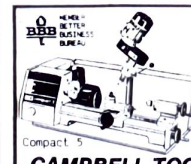

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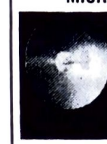

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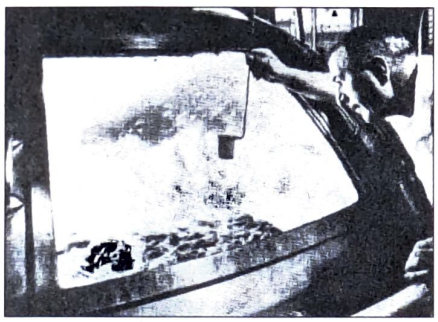

A kettle, such as this one, is used to brew draft beer destined for kegs, bottles, and cans.

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There is a difference between regular draft and nondraft in taste. The difference grows out of a key step in the processing. Brewers are putting real draft beer—the kind formerly sold only from the keg—into cans and bottles.

Traditionally, brewers have prevented bottled or canned beer from spoiling by pasteurizing it—raising the temperatures to 140°F for 15 or 20 minutes—after canning or bottling. This inactivates yeast cells, bacteria, and other organisms that could cause the beer to go bad. But heating also changes the chemical properties of the brew slightly. Within a week or ten days, the typical bottled or canned flavor—a slight harshness as opposed to the more mellow draft taste—becomes noticeable.

Millipore Corp. of Bedford, Mass., makes a filter that allows the beer to retain its draft taste. German scientists had devised a filter of extremely thin cellulose in which the size of individual holes was accurately controlled so that none would be larger than a specified diameter. This so-called membrane filter was adapted by Millipore to become a brewing filter, thereby eliminating the need for pasteurization. With the Millipore filter, brewers now can produce real draft beer in cans and bottles.

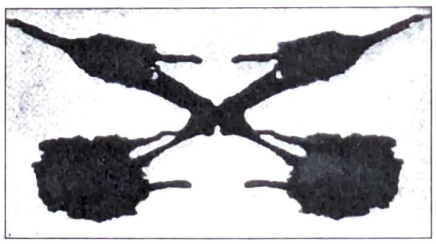
50 YEARS AGO — AUGUST 1942

By projecting a series of carefully prepared ink blots on a screen and asking spectators to write down what each fantastic shape suggests, psychologists are now able to choose suitable men for mechanized units of the armed forces and workers for industrial jobs.

Ink-blot tests, developed nearly 20 years ago by a Swiss psychiatrist named Rorschach, were, until recently, used as a means of carefully diagnosing neurotic or psychotic conditions. In these tests, subjects are shown a series of ink blots. The subjects examine the ink blots one at a time and for each write down what they see. The new projection method, which allows as many as 100 to take the test at one time, has been revised to give a quick picture of an individual's reactions in normal life.

Many different images may be associated with any one of the projected ink blots, and none of these perceived images are right or wrong. But certain images are more frequently seen than others, and every person should "see" a certain number of "popular" images. This indicates the person's ability to see things as other people do.

In scoring the test, examiners are particularly careful to notice whether the subject has observed color, movement, form, or texture. They note just how far the imagination has roamed and whether there is any particular resemblance to the object described. These clues give the examiner a pretty clear picture of how the individual will act in time of stress, what his energies and abilities are, and how he can use them in his environment.



Rorschach ink-blot tests are used to determine placement within the armed forces.

100 YEARS AGO — AUGUST 1892

Opinions still differ with regard to the value of aluminum for use in food-containing vessels. Several months ago in a paper on the subject, it was stated that aluminum was too readily reactive with food or other substances used in cooking for it to be safely used in the construction of kitchen utensils. Afterward, in experiments on the subject, it was concluded that coffee, tea, and beer had practically no reaction with aluminum, and the reaction with brandy was very slight. The action of acids and acid liquids—wine, sour milk, and fruit juices—was more pronounced, but still too slight to cause alarm.

Taking the worst case, it was found that if a liquid with a continual acetic acid concentration of five milligrams per 100 square centimeters remained in a given vessel, that vessel would be reduced to half its original weight in 55 years. This is too trifling an action to be considered.

There is no danger of any injurious action upon the human body by aluminum compounds, which are not poisonous. Before they can act injuriously, a quantity will have to be ingested a hundred times larger than found regularly entering the stomach in this way.

Against these conclusions is a report of a soldier who was taken sick after drinking cognac from his aluminum flask. On analysis of the brandy it was found to be muddy, and to contain roundish, black particles, which proved to be aluminum and iron. But it was not simple corrosion of aluminum but an interaction between the liquor, aluminum, and iron, with a result of corrosion. Further investigation of the subject is needed.

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